

TRIBES AT RISK:

The Wisconsin Tribes Comparative Risk Project

**Final Report
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Preface

"We are part of the Earth and it is part of us. ... All things are connected."

--Chief Seattle

This report was prepared by the Work Group of the Wisconsin Tribes Comparative Risk Project that was supported by the U.S. Environmental Protection Agency (EPA). It documents the risk evaluation of the environmental problems faced by Tribes in Wisconsin. It is the first effort to evaluate the risks faced by Native Americans in a comparative risk framework. The Project was a cooperative effort of the Planning and Management Division in Region 5 (Chicago), the Offices of Policy, Planning and Evaluation (OPPE) and Water (OW) in EPA headquarters, and the eleven Tribes of Wisconsin.

Over the last five years, EPA has supported over twenty comparative risk projects in EPA regions and in states to facilitate better approaches for managing environmental problems. While these projects have revealed many similarities in the seriousness of risks across the country, there were also distinct differences that reflect the environmental diversity of our Nation. Even where risks are similar, the causes of risk sometimes differ, necessitating unique solutions to achieve the greatest reduction in risks for our environmental protection dollar.

Native Americans, with their special relationship to the land and the ecosystems within which they live, different governmental structures and relationship to the U.S. Government, and distinctive cultural influences, may face different types, amounts, and causes of environmental risks than the "typical" American. This pilot project sought to adapt the comparative risk analytical framework to the conditions experienced by the Tribes in Wisconsin to both identify these differences in risks and provide a first step in developing the most effective ways of reducing them.

Most of the analytical work and decision-making for this project was conducted by the Work Group, consisting of professional staff of Region 5, OPPE, and OW. The Tribal Chairs and their staff reviewed, contributed to, commented on, and endorsed the work of the EPA Work Group, as did EPA program analysts and management.

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Contents

Preface	i
Contents	iii
Tables	v
Figures	vi
Executive Summary	vii
I. Introduction	1
A. Background on the Wisconsin Tribes	2
B. Background on the Comparative Risk Process	5
<i>Types of risk</i>	6
<i>The risk assessment process</i>	7
II. Project Methodology	10
A. General Approach	10
B. Modifications of Comparative Risk Methods	14
<i>Overall nature of the comparative risk approach</i>	14
<i>Approach for health risk</i>	16
<i>Approach for ecological risk</i>	17
<i>Approach for social and economic damages</i>	18
<i>Geographic coverage of the project</i>	19
<i>Diversity across the reservations</i>	19
C. Ranking Methods	20
<i>Health risk ranking procedure</i>	20
<i>Ecological risk ranking procedure</i>	21
<i>Social and economic damages procedure</i>	21
III. Project Results	23
A. Health Risk Ranking	23
B. Ecological Risk Ranking	27
C. Social and Economic Damages Ranking	32
D. Data Gaps	35
E. Need for Environmental Protection Infrastructure	38
F. Comparing the Results with Other Studies	39
G. Project Recommendations	42
H. Suggested Next Steps	43

Appendix A: Definitions of Problem Areas Considered for Ranking	A-1
Appendix B: Background Papers on Problem Areas	B-1

Tables

Table 1: Information on Wisconsin Tribes	2
Table 2: Members of Project Work Group	10
Table 3: Environmental Problems Evaluated	11
Table 4: Combined Health Risks	28
Table 5: Cancer and Non-Cancer Health Risks	29
Table 6: Combined Ecological Risks	33
Table 7: Aquatic and Terrestrial Ecosystem Risks	34
Table 8: Social and Economic Damages	36

Figures

Figure 1: Native American Settlements in Wisconsin	3
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Executive Summary

This report describes the results of a project conducted in 1991 and 1992 to evaluate the environmental risks faced by the 11 Native American Tribes in the State of Wisconsin. The study is the first comparative risk project conducted by the U.S. Environmental Protection Agency (EPA) that focuses on Native Americans. The project is a cooperative effort by EPA's Region 5 (Chicago); Office of Policy, Planning, and Evaluation; Office of Water; and the eleven Tribes in Wisconsin.

The Indian Tribes of Wisconsin have a lifestyle, culture, values and environment different than most Americans. Their reservations are relatively isolated and undeveloped and are much more nearly in their natural condition than the land surrounding them. The Tribes rely extensively on harvesting local fish, game and plants for subsistence. They also place high cultural value on preserving the quality of their environment, and seek to manage their activities so as to maintain their lands in undiminished condition for future generations. However, stresses from growing development outside the reservations and pressures for economic growth on the reservations have combined to generate significant environmental problems for the Tribes.

This project has used the standard methods of comparative risk assessment to rank the relative seriousness of the different environmental problems facing the Tribes, given their specific situation. It is a pilot effort to see if comparative risk techniques can provide useful insights when applied in the Indians' distinctive natural and cultural setting. Like all comparative risk projects, the results depend extensively on the judgment of the project work group in evaluating the data that was assembled bearing on the Tribes' environmental problems. The work group conducting the project consisted of representatives from EPA Headquarters and EPA Region 5, including four Native Americans. While not pure science, the analysis and rankings are extremely valuable for setting priorities and developing plans of action for addressing environmental problems that affect the Tribes.

The project has four specific objectives:

- o To determine the relative severity of the different environmental problems facing the Wisconsin Tribes;
- o To learn how the comparative risk framework and methods should be adjusted to fit the unique characteristics of the Wisconsin Tribes;
- o To determine how the risks facing the Wisconsin Tribes compare with those facing broader populations studied in other comparative risk projects; and
- o By gaining a better understanding of the environmental problems facing the Tribes, to provide a start toward managing them better.

Twenty-two environmental problems were ranked separately in terms of the health risks, ecological risks, and social and economic damages they pose to the Tribes. These rankings were

developed through use of standard comparative risk methods, with several modifications to reflect the unique focus on Native Americans. In estimating health risks, particular attention was given to the influence of Tribal lifestyles on exposure pathways. Heavy subsistence consumption of local fish and game was very important. In evaluating social and economic damages, two non-traditional categories of damages were given great weight: damages to Indian cultural and religious values, and damages to subsistence activities. One traditional damage category was also emphasized -- damages to natural resources of commercial value to the Tribes. For ecological risks, traditional assessment methods were not changed. We maintained that the methods and conclusions about ecological risks in a particular area should be the same whether the study is performed from the perspective of Native Americans, the mainstream culture, or any other group.

The environmental problems ranked as most serious for each type of risk were:

Human health risk:

- Food contamination
- Nonpoint source pollution of surface water*
- Indoor air pollution other than radon
- Indoor radon
- Drinking water contamination
- Groundwater contamination

Ecological risk:

- Nonpoint source pollution of surface water*
- SO_x/NO_x (acid deposition)
- Physical degradation of water and wetlands

Social and economic damages:

- Nonpoint source pollution of surface water*
- Physical degradation of water and wetland habitats
- Food contamination
- Physical degradation of terrestrial ecosystems
- Unmanaged hazardous waste sites (past disposal)
- SO_x/NO_x (acid deposition)

Notes:

We ranked all of these problems as "high risk" relative to the other problems studied. Although these problems are listed here for each type of risk in descending order of severity, we are much less confident in this ordering within the high risk category than in the more fundamental distinctions between high, medium, and low risk.

* For this project, the "nonpoint source" category is defined to include all means by which pollutants reach surface water other than from point sources, including runoff, air deposition, and ground-water discharge. This definition differs somewhat from that commonly considered by EPA's Office of Water.

Several of these problems rank very differently than they did in the recent Region 5 comparative risk project, and in other comparative risk projects focusing generally on mainstream American society. This is despite use of similar analytical and ranking methods in each of these studies. Some of the major differences are:

- o Food contamination from environmental sources (except residues of agricultural pesticides) has never been noted as a top problem in other projects. The Indian diet includes large quantities of local fish and game species that have bioaccumulated and bioconcentrated environmental contaminants as a result of being atop lengthy food chains.
- o Problems deriving from industrial activity rank unusually low for the reservations, but often rank high in other studies. There is very little industrial activity on or near the reservations.
- o Problems deriving from long range transport of pollutants rank unusually high on the reservations. To generalize very broadly, most comparative risk projects have found that most of the important risks derive from sources within or near the study area. The reservations, though, face problems deriving largely from pollutant sources farther away and outside the reservations. This has substantial implications for risk management.
- o Most studies find criteria air pollutants to pose high health, ecological and economic risks. On the reservations, by contrast, they pose rather low risks (with the exception of acid deposition). The density of mobile and industrial sources of criteria air pollutants is very low near the reservations.

Another surprising result was that despite the isolated and generally undeveloped character of most of the reservations (largely as a result of most Tribes' conscious choice to avoid industrial development and maintain the natural quality of their land), the Tribes are faced by some serious environmental problems.

Air deposition of PCBs, mercury and other toxics on water and land is perhaps the most important single source of risks. Fish and game have bioaccumulated these toxic chemicals (in a process accelerated by acid deposition) to levels posing substantial health, ecological, and cultural risks to a Native American population that relies heavily on local fish and game for subsistence. As the extent of fish and game contamination is more fully investigated by state and federal authorities, advisories suggesting limited or no consumption of fish and game are being established for a large portion of the Tribes' traditional hunting and fishing areas.

A second important problem facing the Tribes is very high levels of radon for many of the reservations. At 5.8 pci/l, the weighted average indoor radon level substantially exceeds EPA's action level of 4 pci/l across the over 1,000 sampled Indian homes. Conditions exist that would lead to substantial levels of other indoor air pollutants also: a very high incidence of

smoking among the Indian population, general reliance on wood stoves for home heating, a long heating season, and newer, airtight (low ventilation) housing.

The largely natural condition of most of the reservations and the low level of many of the risks facing the Tribes relative to those facing typical urban Americans should not be interpreted to suggest a relatively low level of need for environmental protection for the Tribes. The treaties with the U.S. under which the Tribes ceded some lands and rights and maintained others led to a significant trust responsibility for the federal government. In keeping with that trust responsibility, the EPA Indian Policy of 1984 commits the Agency to considering Tribal concerns and interests whenever its actions may affect reservation environments.

The standard by which the U.S. government judges Indian needs for environmental protection should not only involve comparison of conditions facing the Tribes now with conditions facing other Americans now. It should also involve a historical comparison -- comparing current conditions with those prevailing a century or more ago, when the Federal commitments to the Tribes were made. Other factors which EPA must consider include Tribes' reliance on natural resources for subsistence and the cultural importance of the environment to the American Indians. The treaties, trust responsibility, and EPA Indian Policy require a high level of protection for the reservation environments.

EPA's comparative risk framework tends to emphasize current, demonstrated environmental risks without focusing on how environmental problems may increase in the future. In addition to analyzing the risks from current environmental problems, it is also necessary to consider: a) the need to protect the land and Indian culture from risks for the very long term future, and b) the expected vulnerability of the small amount of reservation land to growing risks from outside the reservations in the future. Comparative risk projects serve as the analytical foundation on which efforts to reduce risk are based. We believe that it is very important to direct environmental management efforts for the Tribes both at current risks (where most of the attention in this project was devoted) and at potential future risks.

The Tribes feel particularly vulnerable to worsening environmental problems in the future for several reasons. The isolation of the reservations has protected them to some degree so far. However, development outside the reservations will continue and pollutants will increasingly flow into the reservations. The Tribes feel powerless to influence the nature and impacts of this development. The Tribes have a nearly complete lack of administrative or physical infrastructure with which they can manage or even influence environmental problems from sources either within or outside of the reservations. For example, Tribal environmental staffs are minimal; there are few Tribal laboratories and minimal environmental monitoring has occurred; there are no air or water quality standards for the reservations; and many drinking water treatment, sewage treatment and waste disposal facilities are substandard.

In addition, the Tribes place high value on their traditional harmonious relationship with their natural surroundings. They are limited in pursuing their traditional activities to the small vestigial reservation areas. These areas must remain undamaged for centuries into the future if

the Tribes are to maintain their ancestral values.

Although our primary intent was limited to ranking the risks facing the Wisconsin Tribes, we have also made some suggestions about where to concentrate in managing the risks. The following is a list of the environmental problems facing the Wisconsin Tribes for which infrastructure development (both administrative and physical) would be most beneficial in order to reduce current risks and avoid growing future risks:

Highest priority for infrastructure development:

Protection of surface water quality (nonpoint, industrial, and municipal sources)
Protection of ground-water and drinking water quality
Municipal solid waste
Aquatic and terrestrial habitat alteration
Radon
Pesticides
Food contamination (both subsistence fish and game, and USDA commodities)

Note that these priorities for infrastructure development are somewhat different than the list of the most serious risks. Several factors in addition to the severity of the risks are considered in developing a priority list for action -- these factors generally include the economic, political, and institutional feasibility of addressing the risks.

After completing the analysis and risk evaluations, we have two recommendations for the use of this project's methods and results: 1) use the analysis and rankings to help guide risk management activities both on the reservations and in EPA and other Federal agency programs; and 2) use the adapted comparative risk methodology in future comparative risk projects with other Tribes.

This project is intended to serve as the analytical foundation to begin a process of planning for activities that will help solve the environmental problems faced by the Tribes. Hopefully, this process will include not only the Tribes and EPA, but also the State, other Federal agencies, industry, and others whose activities affect the Tribes' environment. Priorities for environmental action should reflect the risks faced by the Tribes. The analysis and rankings from this project, together with consideration of cost-effectiveness, technical, legal, and political feasibility, can help in identifying and developing strategies and Tribal environmental programs that will deliver effective solutions to environmental problems.

I. Introduction

Since 1986, the U.S. Environmental Protection Agency (EPA) has performed or supported about twenty-five comparative risk projects, aiming to evaluate the environmental risks facing different regions, states or cities within the U.S. Each of these projects has focused on the entire, diverse population of Americans living within the geographic boundaries of the study area. EPA's Regional and State Planning Branch (RSPB), which supports comparative risk projects in EPA Regions and states, has been interested in supporting Tribal comparative risk analysis to complement Regional and State projects. Recently EPA has become more concerned with the equity of environmental protection programs for particular minority subpopulations. The RSPB has also been interested in investigating how the risks facing different subpopulations differ from Regional and State averages. Region 5 was particularly interested in investigating how risks differ for the eleven Native American Tribes in Wisconsin. Early in the project, EPA's Office of Water (OW) joined in collaboration with the Office of Policy, Planning and Evaluation (OPPE) and Region 5, because many of the risks faced by the Wisconsin Tribes were most likely related to water issues.

In this project we have used the methods of comparative risk analysis to assess and rank the environmental risks facing a very specific minority population -- members of the eleven Native American Tribes living in Wisconsin. Comparative risk methods have been modified somewhat to better reflect the problems and values of Tribes. The 20,000 to 30,000 members of the Wisconsin Tribes both live in a setting and pursue a lifestyle quite different from those of the average American. The Indian reservations in Wisconsin are rural, thinly populated and largely undeveloped. The Indians place great value on maintaining a traditional harmonious relationship with their natural environment, and they rely extensively on subsistence hunting, fishing and gathering. Not surprisingly, therefore, the pattern of environmental risks facing the Wisconsin Indians is rather different than that facing the average American.

The project has four specific objectives:

- o To determine the relative severity of the different environmental problems facing the Wisconsin Tribes;
- o To learn how the comparative risk framework and methods should be adjusted to fit the unique characteristics of the Wisconsin Tribes;
- o To determine how the risks facing the Wisconsin Tribes compare with those facing broader populations studied in other comparative risk projects; and
- o By gaining a better understanding of the environmental problems facing the Tribes, to provide a start toward managing them better.

A. Background on the Wisconsin Tribes

Eleven Tribes or bands of Native Americans now live in Wisconsin. Most of these Tribes are native to Wisconsin, although two (the Oneida and the Stockbridge) moved to Wisconsin from New York and New England over a century ago. The historical range of these Tribes was far greater than their current reservations -- Indian rights to vast areas of Wisconsin were ceded to the U.S. in a series of treaties in the mid-1800's. Nearly all of the current reservations for the Tribes in Wisconsin were established in treaties during the period of 1831-1873, or by Acts of Congress from 1913-1939. Figure 1 shows the location of the current reservations. Table 1 provides additional information on each of the Tribes.

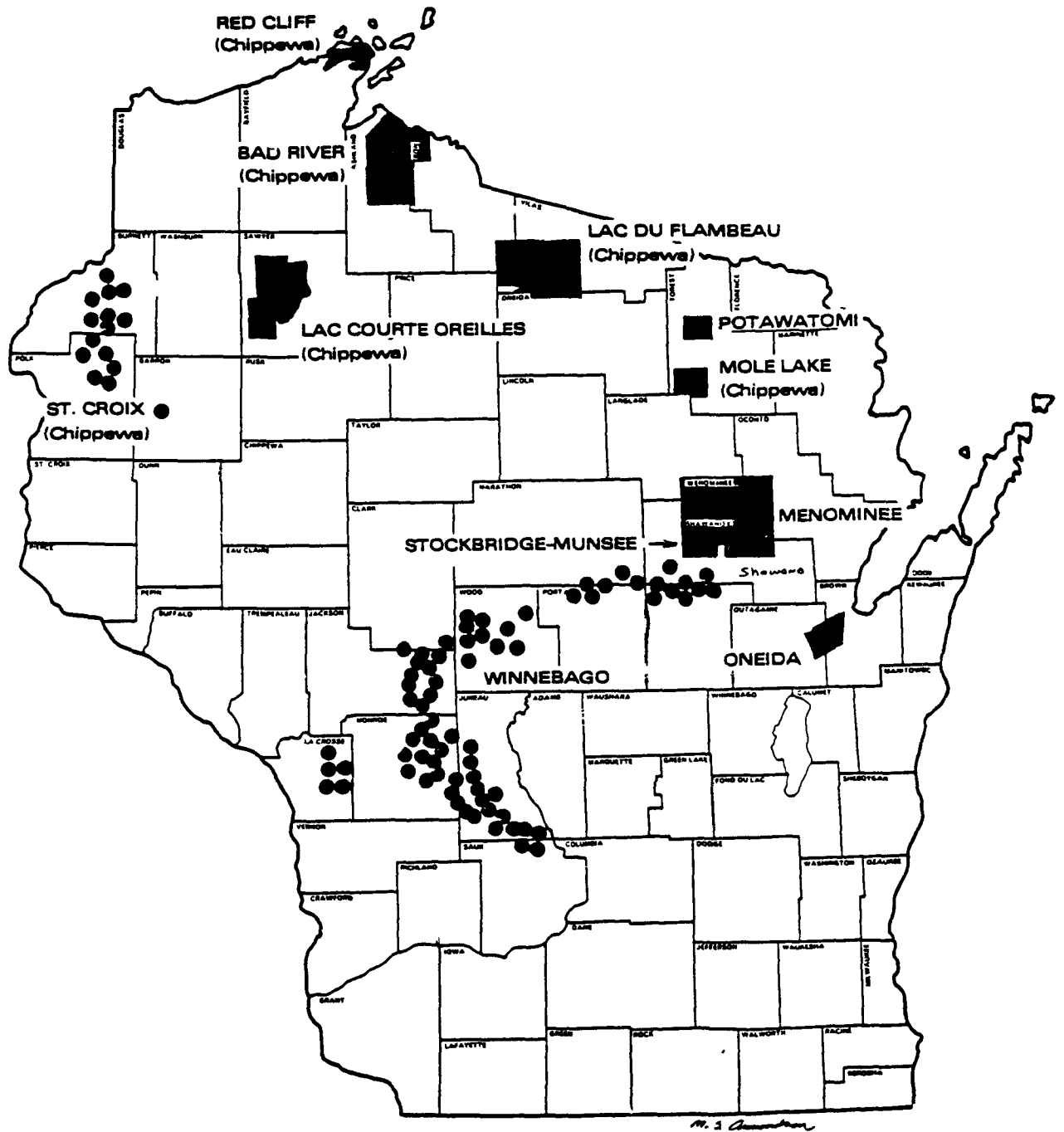
Table 1: Information on Wisconsin Tribes

Tribe	Origin	Members on/near res.	Reservation Area (acres)	Tribally Owned (acres)	Reservation Established (year)
Bad River	Native/Chippewa	1,431	124,000	56,345	1854
Lac Courte Oreilles	Native/Chippewa	2,279	75,000	43,610	1873
Lac du Flambeau	Native/Chippewa	1,485	92,000	30,303	1854
Menominee	Native	3,582	235,000	222,522	1854
Mole Lake	Native/Chippewa	343	1,694	1,694	1939
Oneida	New York	4,437	65,730	2,741	1831/1838
Potawatomi	Native	466	11,692	11,692	1913
Red Cliff	Native/Chippewa	1,391	14,100	7,569	1854
St. Croix	Native/Chippewa	1,209	2,371	1,940	1938
Stockbridge-Munsee	New England	826	46,000	16,028	1856
Winnebago	Native	1,912	4,265	4,265	1963

Federally recognized Indian Tribes are sovereign dependent nations that have developed a trust relationship with the U.S. government. Through treaties with the U.S., Tribes have relinquished title to most of their historical lands, but in many cases have retained certain rights to use of the lands, as well as the right to govern themselves. Particularly important in Wisconsin, a 1983 court decision has declared that the Chippewa Tribes still maintain their historical rights to fishing, hunting and gathering throughout the northern 40% of the state despite the 1837 and 1842 treaties that ceded this land to the U.S. (the "Voigt Decisions": Lac Courte Oreilles v. Voigt, 700 F. 2d 341 (7th Circuit 1983) et. seq.).

Most Indian Tribes have the right to exercise civil and certain criminal authority over their reservation lands. State powers over these lands are sharply limited. Under the Constitution, the Federal government can regulate many aspects of Indian life. Court decisions have also declared a special responsibility of the federal government toward Indian Tribes -- to act as "trustee" on behalf of and for the benefit of Indian Tribes. In an environmental context, the unique legal position of Indian Tribes has resulted in Tribal authority to establish environmental standards for the reservations (independent of state standards, but consistent with any federal minimum standards) and a federal responsibility to contribute to the achievement of the standards.

Figure 1: Native American Settlements in Wisconsin



Most of the Wisconsin Indian reservations are thinly populated, rural, relatively isolated and undeveloped. The primary economic activities on most of the reservations involve natural resource development -- logging, sawmills, fishing, hunting, wild rice gathering and cranberry farming. Tourism provides some income, with lakeshore cottages and resorts, cultural events, and guided fishing and hunting. Commercial activities are limited but growing, with Tribal government offices, community centers, health clinics, grocery stores, gas stations, and the like having been developed at an accelerating pace. Several reservations have developed profitable gaming enterprises and associated motels, which draw many non-Indians. Heavy industry is non-existent on the reservations, and there are only a handful of light industrial plants. Except for wild rice and cranberry harvesting, agriculture is of little importance on most reservations. Only the Oneida and St. Croix reservations have been significantly transformed by agricultural development. Nearly all of the land on the other reservations is in natural or managed forests, lakes and wetlands.

Economic conditions on the reservations are generally depressed. Unemployment is very high. Many of the business ventures started by the Indians have failed. Both as a matter of cultural tradition and because of limited incomes, the Indians rely heavily on locally harvested fish, game and grains for their food supply. Schools, health care and housing are heavily supported by the Federal government, and are adequate.

As might be expected with so little development, environmental conditions on the reservations are quite good compared with those faced by most Americans. Air and surface water quality are excellent relative to typical conditions elsewhere in the U.S.. Chemical contamination of drinking water sources on the reservations is rare and most reservation residents obtain drinking water of good chemical quality from untreated ground-water wells. Fish and game are abundant by comparison with other areas in the U.S.. (although they are not as abundant as they were historically in the local area, and some species such as mink, eagles and otters are clearly stressed). Pesticide use on the reservations is minimal, and hazardous wastes are neither produced nor disposed in significant quantities on the reservations (with the exception of small quantities of medical wastes).

Despite these generally good conditions, the reservations do have some important environmental problems. Long range transport of contaminants (acids, mercury, PCBs and others) and their deposition from the air have led to bioaccumulation of contaminants in fish and game. To heavy subsistence consumers of local fish and game, these contaminants pose substantial health risks. Naturally occurring contaminants -- radon in soil and metals in ground water -- are problems in some areas.

The lack of facilities for avoiding or mitigating potential environmental problems generated on the reservations is also worrisome. Sanitary and bacteriological problems are particularly likely, though monitoring data generally do not exist for documenting the presence or absence of such problems. Most reservation households rely on septic systems for domestic waste disposal. Many of the septic systems are known to be in very poor condition, often discharging directly to lakes or the land surface. Most households get their drinking water from

shallow, untreated, and often poorly constructed private wells. Although chemical contamination is rare, bacteriological contamination of drinking water supplies from septic fields affecting the wells is likely. The public systems for drinking water supply and for wastewater collection and treatment are also problematic. Most of the community water supply facilities provide no drinking water treatment whatsoever; most of those providing some treatment do not maintain a sufficient chlorine residual to protect against bacteriological contamination. Many of the wastewater treatment facilities are in poor condition, and several consistently violate their permit requirements. Most of the solid waste from reservation households was historically open dumped. None of the many scattered landfills on the reservations have adequate operating procedures, cover, site security, leachate collection, rodent control or monitoring. In sum, the facilities to protect reservation residents from environmental problems that they may generate themselves are inadequate by common standards. To the extent that environmental problems of a sanitary or microbiological nature are modest on the reservations, it is entirely because the density of habitation is low. The engineered environmental systems on the reservations provide little protection against such risks.

Tribal officials are also worried about another source of vulnerability to environmental risks -- there is little legal and management infrastructure directed at understanding and mitigating environmental problems. Tribal environmental staffs are small or nonexistent. No Tribal ambient air or water standards have been developed. Monitoring efforts are limited, with large gaps in data. The Tribes have little ability to influence pollution sources outside the reservations that affect reservation lands or the off-reservation areas where fishing and hunting rights have been retained.

B. Background on the Comparative Risk Process

The comparative risk process is a means of setting priorities among environmental problems. American society is now faced by a bewildering variety of environmental problems - - problems that involve numerous different pollutants, sources, and exposure pathways and that can affect human health, ecosystems, and social and economic values in many adverse ways. The problems in total exceed the resources for dealing with them. Which problems should environmental managers work hardest to solve? How can limited resources be focused to achieve the greatest improvement in our environment? The comparative risk process allows risk managers to allocate limited time and financial resources to address and remediate those hazards deemed pose the greatest risks to human health and the environment.

In the first stage of a comparative risk project, the environmental problems facing a geographic area of interest are compared in terms of the severity of the risks they pose. In these projects, analysts review available data on the full range of environmental problems facing the area, evaluate each problem using a consistent analytical framework, and set priorities among these problems in terms of the human health and ecological risks, and, for many projects, the economic and social damages that they pose. The different environmental problems are ranked in terms of their relative seriousness. With this understanding providing a critical background,

the second stage of a comparative risk project involves deciding what to do about the environmental problems. Following completion of their risk analyses, project managers use the analyses and other factors to identify and develop strategies that will deliver the greatest risk reduction potential for the resources invested. Plans are developed for addressing the problems.

The first stage of the comparative risk process thus requires assessing and comparing risks, and the second involves decisions about managing risks. These two stages are kept separate, with the first stage being conducted by individuals with a more technical and scientific orientation, and the second stage being conducted by personnel with broader concerns for the administrative, legal, economic, and political aspects of environmental policy. The Wisconsin Tribes project to date has focused on the first of these two stages -- risk assessment.

While comparative risk evaluations reveal many similarities in risks across the country, they also reveal distinct differences that reflect the environmental diversity of our Nation. Even where the risks are similar, the causes of risk sometimes differ, necessitating unique solutions to achieve the greatest risk reduction for our environmental protection dollar. As resources to finance environmental protection become more and more scarce, it is imperative that we make our investments as wisely as possible. Comparative risk helps us to do that by suggesting where our efforts can do the most good.

Types of risk

In most comparative risk projects, including this one, three varieties of risk are considered: to human health, to ecological systems, and to social and economic values. Definitions and examples of these three types of risk are:

Health risk: cases of human disease or injury caused by the environmental problem. Health effects can range from cancer (e.g., lung cancer from indoor radon) to problems involving the nervous system (e.g., from mercury) to gastrointestinal disease (e.g., from pathogens in drinking water) to injuries (e.g., from accidental releases) to numerous other non-cancer effects.

Ecological risk: damage to the structure and function of natural ecosystems caused by the environmental problem. Some examples include: eutrophication of water bodies from nutrients in nonpoint source runoff, loss of species' range, breeding grounds and other effects from physical modification of habitat, and forests with reduced growth rates and increased susceptibility to pests due to acid deposition.

Social and economic damages: losses to social or economic values caused by the environmental problem. Examples from this project include: reduced commercial or subsistence fishing yields from polluted water bodies, increased maintenance expenses for buildings and other materials exposed to acid deposition, costs of replacing or treating contaminated drinking water supplies, and costs of medical treatment and lost productivity for individuals suffering adverse health effects. Also included under social and economic damages are intangible losses, such as the cultural losses resulting from fewer eagles and other species of religious significance, and the

adverse effects of odors or reduced visibility associated with air pollution.

The risk assessment process

In the simplest sense, risks from environmental pollutants are a function of two measurable factors: hazard and exposure. To cause a risk, a pollutant has to be both toxic or cause stress (present an intrinsic hazard), and be present in the environment at some significant level (thereby coming in contact with humans, plants, animals or materials of economic or cultural value). Risk assessment interprets the evidence on hazard and exposure, judging whether or not an adverse effect will occur, and usually making the necessary calculations to estimate the extent of total effects.

STEPS IN RISK ASSESSMENT

1. Hazard identification involves weighing the available evidence and deciding whether a substance causes a particular adverse effect. Most attention has focused on human health effects, particularly cancer, but hazard identification extends to ecological impacts (e.g., would suspended sediment in water harm fish reproduction?) and to social and economic damages (e.g., would acid deposition reduce profits from forestry?) also.

2. Dose-response assessments determine potency -- how strong a particular adverse effect is caused by a pollutant at various levels of exposure or dose.

3. Exposure assessment entails estimating the concentrations, frequency and duration of exposure by humans or other receptors to pollutants of concern, the routes or pathways of exposure (how the pollutant gets to the receptor), and the number of receptors exposed for various combinations of exposure and pathways. The best method is direct measurement or monitoring of ambient conditions, but this is often prohibitively expensive. In practice, risk assessors usually rely on estimates of emissions and limited monitoring information, combined with mathematical models that estimate resulting concentrations.

4. Risk characterization estimates the risk associated with the particular exposures in the situation being considered. While the final calculations are often straightforward (exposure multiplied by potency equals risk), the way in which the information is presented is important. The final assessment should display all relevant information, including such factors as the nature and weight of evidence for each step of the process, the estimated uncertainty of the component parts, and the distribution of risk across various sectors of the population.

The general risk assessment paradigm serves as a guide in conducting comparative risk analysis, but it is typically applied quite loosely because of the broad scope of the necessary analysis.

One might imagine conducting a traditional risk assessment for all the pollutants associated with each problem area, summing across pollutants, and then comparing the estimated risks for each problem. In fact, that would be an impossibly large task. Most problem areas involve numerous pollutants (sometimes potentially thousands), each of which may cause several damaging effects, and each of which occurs in thousands of different patterns of exposure across the study area. The risk analysis methods used for comparative risk projects generally consist of:

- o Identifying representative or typical exposure scenarios for representative or key pollutants associated with each problem area,
- o Estimating risks for the chosen scenarios using generally available information on hazards and dose-response relationships, and
- o Scaling up or extrapolating from the portion of the problem area that can easily be analyzed to the entire problem area.

The risk assessment process conducted in a comparative risk project is thus different from the typical scientific risk assessment process that is often conducted for a single chemical or a single contaminated site. Because of the extremely broad scope of a comparative risk project, it is not possible to marshal enough resources to complete a full quantitative risk assessment on each problem area before comparing and ranking them. Full risk assessment, in which data on emissions and ambient concentrations are collected, exposures are modeled, and ultimate impacts are projected, is very costly. In the Wisconsin Tribes project, then, we collected and analyzed available data on environmental conditions in the Wisconsin reservations, but supplemented the data extensively with judgment. The judgments derived from work group members' professional knowledge, from results of risk studies in nearby areas thought likely to be similar to the Wisconsin reservations, and from experience gained in previous comparative risk studies elsewhere.

Note that even if resources for the Wisconsin Tribes project had been unlimited, judgment would still have been necessary. Risk analysis is an uncertain process. Subjective interpretation of the results of any risk analysis is always necessary, weighing the strength of the data base used and the validity of the assumptions made.

In sum, the findings of the Wisconsin Tribes project, as for any comparative risk project, should be viewed more as the informed judgment of those performing the project than as the results of a scientific risk assessment. The comparative risk process utilizes data when available, although often times data does not exist. One of the beneficial outcomes of a comparative risk exercise is the identification of data gaps. The comparative risk process is an ongoing,

developing process, not a final, conclusive report. The results are a mix of scientific data, formal and informal analyses, and much best professional judgement. We collected large amounts of data and conducted extensive analyses. We took pains to make our judgments, where necessary, in a systematic and objective fashion. The rankings were done with carefully developed methodologies. Although the methods were not perfect, they imposed consistency and objectivity in each problem area. In addition, we conducted analyses and developed rankings in collegial fashion, with the entire group questioning and debating major points.

The process and results of our deliberations documented in this report were reviewed and endorsed by the eleven Wisconsin Native American Tribes. The report was also reviewed by technical staff in each of Region 5's media Divisions and Office of Health and Environmental Assessment, whose comments, as well as those of the Tribes, were incorporated.

II. Project Methodology

The objective of the project was to evaluate and rank the environmental problems facing the eleven Wisconsin Tribes. The problems were to be ranked in order of severity, from most serious to least. We relied largely on a traditional comparative risk approach to achieve this objective.

A work group consisting of officials from EPA Headquarters and Region 5 was established to conduct the project. Half of the work group members are Native Americans. Table 2 lists the members of the work group and the contractor who provided analytical support.

Table 2: Members of Project Work Group

Kestutis Ambutas	Indian Coordinator, EPA Region 5
Diane Davis	Indian Coordinator, Office of Water, EPA Headquarters (beginning June, 1992)
Steve Dodge*	Indian Environmental Liaison for Wisconsin, EPA Region 5
Ed Fairbanks*	Indian Environmental Liaison Minnesota, EPA Region 5
John Haugland	Planning and Assessment Branch, EPA Region 5
Ron Korn*	Intern, Menominee Tribe
Caren Rothstein	Indian Coordinator, Office of Water, EPA Headquarters (through October, 1991; currently Indian Coordinator, EPA Region 8)
Catherine Tunis	Regional and State Planning Branch, Office of Policy, Planning and Evaluation, EPA Headquarters; also Office of Water, October, 1991 through January, 1992)
Lysa Twocrow*	Intern, Sioux Tribe

* Native Americans

Also: Stuart Sessions; Contractor, Environomics, Inc.

We took the steps described below.

A. General Approach

1. Establish plans and ground rules. We decided to evaluate the same list of environmental problems with the same problem definitions as has been used in most of the Regional comparative risk projects, including the project conducted by Region 5. Making the

list of problems the same in the Wisconsin Tribes project as in the Region 5 project would facilitate comparing the ranking results across the two projects. The environmental problems evaluated in the Wisconsin Tribes project are listed in Table 3. Eventually one problem not evaluated individually in the Region 5 project -- food contamination -- was found to be of sufficient importance to the Wisconsin Tribes that it warranted addition to the Region 5 list. Two problems that were found by Region 5 to pose significant risks -- global warming and stratospheric ozone depletion -- were not studied in this project, because information on them and their rankings would probably be exactly the same for the Tribes as for the entire region.

Table 3: Environmental Problems Evaluated

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- | | |
|-----|--|
| 1. | Industrial wastewater discharges to lakes and rivers |
| 2. | Municipal wastewater discharges to lakes and rivers |
| 3. | Nonpoint source discharges to lakes and rivers |
| 4. | Aggregated public and private drinking water supplies |
| 5. | Aggregated ground-water contamination |
| 6. | Physical degradation of water and wetland habitats |
| 7. | Storage tanks |
| 8. | Hazardous waste sites with active disposal (RCRA) |
| 9. | Hazardous waste sites with past disposal (Superfund) |
| 10. | Industrial solid waste sites |
| 11. | Municipal solid waste sites (including open dumps) |
| 12. | Accidental chemical releases to the environment |
| 13. | Pesticides |
| 14. | Food contamination |
| 15. | Sulfur oxides and nitrogen oxides (including sulfates and acid deposition) |
| 16. | Ozone and carbon monoxide |
| 17. | Airborne lead |
| 18. | Particulate matter |
| 19. | Hazardous/toxic air pollutants |
| 20. | Indoor air pollutants other than radon |
| 21. | Indoor radon |
| 22. | Physical degradation of terrestrial ecosystems/habitats |
-

Definitions of these problems are listed in Appendix A. For a few of the problems, the specific definition -- what is included and what is excluded -- has a particularly important effect on how the problem was eventually ranked. Definitions that should be noted include:

- o Nonpoint source discharges include air deposition and discharge of contaminated ground-water (e.g., from septic systems) as well as runoff.
- o Food contamination includes all contaminants in food from environmental sources. It thus includes pesticide residues.
- o Hazardous air pollutants include effects only while the pollutants are airborne.

The reader should also note that the definitions used result in double-counting of some environmental risks -- the same risk may be counted under more than one problem. Thus, for example, leachate from a municipal waste dump that contaminates ground water that is used as a drinking water supply is counted under three problems: municipal solid waste sites, ground-water contamination, and drinking water supplies. Some earlier comparative risk projects attempted to define environmental problem areas mutually exclusively, so that there was no double-counting of risks. This approach led to confusion when the project's analysis was used because risks typically thought to be associated with given environmental problems may or may not have been included in the definition used. Subsequent projects have opted to use problem definitions with some double-counting of risks in order to lessen this confusion. The most important instance in this project where a risk is counted under multiple problems involves air deposition of mercury and PCBs that are bioaccumulated and bioconcentrated, and are eventually consumed by Native Americans as they eat fish or game. Risks resulting from this sequence are counted under nonpoint sources and under food contamination, but not under hazardous air pollutants.

We decided to rank the environmental problems based upon each of three different types of risk that they pose: to the health of the members of the Tribes, to the natural ecosystems of the reservation lands, and to the social and economic well-being of the Tribes. Each type of risk required somewhat different data and analytical techniques, and the rankings of problems were quite dependent on the type of risk at issue (e.g., some problems posed serious health risks but minimal ecological risks, and some problems showed the opposite pattern).

We also decided to adopt a "residual risk" ground rule. Under this approach, all the risks that will eventually ensue from the current level of an environmental problem are evaluated. The current level of the problem reflects the current degree of compliance or noncompliance with environmental control requirements. Problem area rankings based upon residual risk should be interpreted carefully:

- o Under the residual risk approach, an environmental problem might appear to pose low risks for either of two very different reasons: the problem intrinsically poses low risks, or it intrinsically poses high risks that have been reduced to low levels

by an effective control program. The control program holding risks to a low level may be quite important. One should not simply assume that a problem posing low residual risks warrants minimal control efforts.

- o Residual risks relate to the current level of the environmental problems. Trend information -- instances where an environmental problem is improving or worsening over time -- is unlikely to be reflected in rankings based upon a snapshot of the problems as they currently exist.

2. Acquire data and conduct risk analysis. We acquired existing information pertaining to the environmental problems affecting the Wisconsin Tribes. We developed a preliminary list of desired information on each environmental problem, and the likely sources of such information were then contacted. Much of the desired information proved not to exist. In other cases, because of limitations of time and budget, some of the desired information could not be obtained. Nevertheless, the information acquired was sufficient to characterize at least roughly the nature of each of the environmental problems as they affect the Tribes. The primary sources from which data were obtained included: the Tribes themselves, Wisconsin State agencies, EPA Region 5, the Indian Health Service (U.S. Department of Health and Human Services), the Bureau of Indian Affairs (U.S. Department of the Interior), and EPA Headquarters. Much of the data was acquired by two Indian student interns hired for this purpose.

The contractor for the project summarized the available data and performed analyses using the data to estimate the risks associated with each problem area. The findings for each problem area were summarized in a series of papers for the entire work group. These papers are included as Appendix B to this report.

3. Rank the environmental problems. We met for two full days to discuss the findings and rank the environmental problems in terms of the severity of the risks they pose to the Wisconsin Tribes. We developed ranking criteria and procedures for this purpose that are described in the remainder of this chapter.

Our ranking relied both on the quantitative data and analysis generated for each problem, and on the collective judgment of the work group members. For each problem area, the paper summarizing the available data and risk calculations was reviewed and discussed. Individual work group members added additional relevant professional information or experience. A group discussion ensued and continued until consensus was reached on how a particular problem should be ranked. The work group's combination of some individuals with a close knowledge of Tribal lifestyles and conditions on the reservations with other individuals with extensive experience in comparative risk analysis was very productive in achieving as accurate a portrayal of the relative risks to the Tribes as was possible within the time and resource constraints of the project.

4. Develop a final report. The contractor for the project drafted a report summarizing the project results. We reviewed and modified the draft, producing an interim report from the project. In 1992, the project results and interim report were presented to the 11 Wisconsin Tribes

for their review. This final project report was then developed in conjunction with the Tribes and other reviewers at EPA.

Over the course of the project, we convened formally for four one-day or longer meetings. During the analysis and ranking phase of the project we held bi-weekly conference calls, while during the remainder of the project conference calls were held approximately monthly. We held two meetings with representatives of the Wisconsin Tribes in order to review the draft project findings and solicit Tribal comments.

B. Modifications of Comparative Risk Methods

This set of project activities conducted for the Wisconsin Tribal project is consistent with those typically undertaken in comparative risk projects. However, there was a qualitative difference between the Wisconsin Tribes project and other comparative risk studies in terms of level of effort. The Wisconsin project was a pilot comparative risk project, intended to learn quickly about the nature of the environmental risks facing the Wisconsin Tribes and to investigate how the general comparative risk methodology could be applied to a specific sub-population. The amount of resources applied to the Wisconsin project (work group time and contractor effort) was somewhat less than in other projects, and the data gathering and analysis were performed rapidly. Nevertheless, we felt reasonably confident in the conclusions we were able to draw.

In several meetings throughout the project, we considered the degree to which the standard comparative risk analytical methods should be used to evaluate the distinctive environmental issues facing the Wisconsin Tribes. The following issues were discussed and resolved.

Overall nature of the comparative risk approach

The comparative risk approach has typically been used to compare the severity of environmental problems in geographic areas that now have at least several substantial problems. It has indicated which current, residual risks are the worst, and has thus provided important information in helping to set priorities for risk reduction efforts.

For the Wisconsin Tribes, however, the situation may be somewhat different. An equally important objective in environmental management for these Native Americans may be not only to reduce current environmental risks, but also to prevent these risks from increasing in the future. This is not to say that the environmental problems currently facing the Tribes are not significant -- some clearly are. But avoiding potentially greater problems in the future is also important. We were interested in both using the comparative risk process to elucidate the current risks facing the Tribes, and in providing some analysis that was more forward-looking.

We were also concerned about how the environmental risks currently facing the Tribes might look when compared with those existing elsewhere. By comparison with the rest of the country, the areas in which the Indians live are relatively pristine and free from environmental

problems. But this does not mean that these problems -- current and future -- are only worthy of little attention. To the contrary, we believe that at least some of the Tribes' environmental problems may need much more attention because:

- o The treaties with the U.S. under which the Tribes ceded some lands and rights and maintained others prescribe a significant trust responsibility for the U.S.. The standard by which the U.S. government judges Indian needs for environmental protection should not only involve comparison of the conditions facing the Tribes now with conditions facing other Americans now. It should also involve a historical comparison between current conditions and those prevailing a century or more ago, when the Federal commitments to the Tribes were made. It should also involve a view toward future vulnerabilities. The treaties and trust responsibility require a high level of environmental protection for the reservations and the surrounding lands on which Indian subsistence rights are retained.
- o The Indians are extremely vulnerable to increasing environmental problems in the future because they lack the technical, administrative and financial infrastructure necessary to ward off these problems; and
- o The Native American culture is uniquely dependent on maintaining a pristine environment in their historic reservation lands and fishing and hunting grounds. For the Indians, moving from their reservation lands is not a legally or culturally acceptable alternative. Even small damages to the reservation environments that seem modest to outsiders can have significant religious or economic impacts on Tribes that rely on the natural environment for subsistence.

In effect, two separate questions were raised about whether the traditional comparative risk framework was sufficient as an analytical foundation for planning actions for a better environmental future for the Tribes:

1. Is the focus on risks from the current levels of environmental problems appropriate, or might it be more useful to focus on comparing the risks from the likely future levels of the environmental problems?
2. Should we conclude our efforts upon ranking the various risks facing the Tribes, or should we continue on to provide some ideas about priorities in managing the risks that have been assessed? Traditional comparative risk projects have separated the process of risk assessment (what is the relative severity of the various risks) from risk management (what should be done about the risks once they have been assessed).

We resolved these questions by deciding: a) To conduct a traditional analysis of current residual risks, and b) To go further and identify the problems for which investment in enhanced environmental protection efforts will do the most to reduce current and future risks. With regard to the first question, the methodology for comparing projected future risks has not yet been

developed for EPA comparative risk projects. The data needs and resources required to develop such a methodology are beyond the scope of this project. In addition, the traditional comparative risk analysis held some promise of showing that the pattern of risks facing the Wisconsin Tribes is rather different than the pattern of risks facing the average American -- and thus that Indian environmental priorities need special attention. This analysis of current risks would serve as the starting point if a comparative analysis of future risks is ever initiated. On the second question, we decided to develop preliminary judgements about the best investments for reducing risks because of the considerable effort we made in evaluating the risks from each environmental problem and the causes of those risks. This evaluation is a crucial first step in any deliberation about risk management. A further discussion of the best opportunities to reduce current and future risks facing the Tribes is included in the final chapter of this report.

Approach for health risk

We discussed whether modifications were needed to traditional health risk assessment procedures in order to make them applicable to Native Americans, and if so, what modifications. Two specific issues were discussed:

1. The demographic and health profile of the Wisconsin Tribes is rather different than that of the general population. The average age of the Indians on the reservations is substantially less than that of the general population, cancer incidence is generally higher, smoking is more common, health care may be less available, and a range of other factors are different. There may also be important physiological differences between the races that affect susceptibility to environmentally induced diseases. We considered how these differences should affect estimation of health risks.

Our consensus was that such differences are important in situations when health risk estimation depends either on data on incidence of health effects among the Indians (e.g., data on incidence of gastrointestinal diseases may be used to provide information about the risks from microbiological contamination of drinking water) or on epidemiological relationships that can be corrected for cross-cultural differences in risk factors (e.g., epidemiological relationships between blood lead and learning disabilities can be adjusted to fit the age distribution of the Indian population). These differences were judged not to be important, though, when health risk assessment is based upon traditional calculations where dose is multiplied by potency for environmental pollutants with health effects information derived from animal studies. Uncertainties already inherent in the standard health effects data resulting from extrapolation from animals to humans and from other causes are undoubtedly far more significant than any errors that might result from not considering racial differences between Indians and the general population. In general, then, data on potency of environmental pollutants was taken from standard EPA data bases (e.g., the Integrated Risk Information System) and applied to Native Americans just as it is applied to the general population.

2. The character of the exposure to environmental pollutants for members of the

Wisconsin Tribes may be substantially different than it is for members of the general population, as a function of culture, lifestyles, and the very rural setting for the reservations. For example, the Wisconsin Tribes obtain a large portion of their food through local hunting, fishing and gathering. One estimate is that the Chippewa Tribes obtain 50-90% of their fruits, vegetables, grains, meat, fish, poultry, and sweets from local harvesting. For the Indians, health risks from food consumption depend substantially on the levels of environmental contaminants in the local area that may be bioaccumulated in fish, game, grain or fruits. For the general population, by contrast, food consumption risks depend much more on the level of contaminants in nationally marketed, mass-produced, and often Federally-inspected foodstuffs. It would be a serious mistake to assume that the Indians' diets, and hence their pattern of exposure to contaminants in food, are similar to those of the general population.

We agreed that the major challenge in the health risk approach was to estimate accurately the unique Tribal patterns of exposure to environmental pollutants. In some cases this was possible. Data was obtained specifically for Native Americans on, for example, subsistence food consumption and on reliance on private wells for drinking water. Based on such data, it appears that the average Native American consumes about five times as much fish as does the average American. In other cases it was not possible to obtain exposure data particular to the Wisconsin Tribes -- we could find no basis for improving on the standard assumptions that an adult drinks 2 liters of water and breathes 20 cubic meters of air per day.

In sum, when assessing health risks, we thought it important to improve on standard comparative risk assumptions in estimating Indian exposure to pollutants, but we were generally willing to use the traditional assumptions for estimating the potency of these pollutants.

Approach for ecological risk

In evaluating ecological risks, we decided to employ traditional comparative risk approaches. Ecological risk assessment requires a scientific evaluation of the health of the subject ecosystem and threats to it. We believed this evaluation should focus on the structure and processes within the ecosystem independent of the uses one wants to make of the ecosystem or the values one wants to ascribe to it. The results of an ecological risk assessment for a particular area should be the same whether the study is performed from the perspective of Native Americans, the mainstream culture, or another group. The ecological rankings thus are not culturally based. Culturally important aspects of the ecosystems on and around the reservations are evaluated under other varieties of risk:

- o Risks from food consumed from the ecosystems are covered under health risks.
- o Religious, cultural, and economic values associated with the ecosystems are covered under social and economic damages.

Approach for social and economic damages

This portion of the study involved adjustments to traditional comparative risk methods. Social and economic damages encompass damages to all of the values held by the population being studied. Many Native Americans' values differ significantly from those of the general population, as a result of culture, religion and the different economic pursuits of the Tribes. Typical methods for evaluating social and economic damages often involve converting disparate damages into dollar estimates to provide a common metric for comparison. We felt that this approach would not capture some social damages that are particularly important for the Tribes which involve non-marketed and difficult-to-value activities (e.g., damages to subsistence hunting or fishing, cultural losses due to the reductions in numbers and health of eagles over time and area of wild rice beds). Many of the methods typically used in valuing economic damages (e.g., value of a recreation day, functions relating concentrations of particulate matter to soiling damages) cannot appropriately be extrapolated to Tribal culture, and few are applicable.

We decided to use a more qualitative approach to assessing social and economic damages. We developed a list of categories of potential social and economic damages that are important from a Tribal perspective. These damage categories included:

- o Diminution of cultural and religious values
- o Damage to subsistence activities (e.g., non-commercial hunting, fishing, gathering)
- o Damage to natural resources in commercial use (e.g., timber, fisheries, hunting, trapping)
- o Damage to tourism and commercial recreational services
- o Health care costs and lost productivity
- o Material damage and soiling
- o Reduced recreational opportunities
- o Damage to water supplies
- o Aesthetic effects

We decided that the first three of these damage categories were more important to the Tribes than the others. Our ranking procedure involved reviewing the extent to which an environmental problem caused damages in each of these nine categories, weighting the first three more heavily, and then summing the results across all the damage categories. This ranking procedure is described more fully in the next section of this chapter.

Geographic coverage of the project

Most comparative risk projects have focused on a defined geographic area, and have assessed risks to the people and ecosystems within the area boundaries. Issues associated with transport of pollutants into or out of the study area have caused difficulties.

The study of the Wisconsin Tribes has been somewhat different. The focus here is on the risks affecting a specific group of people and on the ecosystems on which they rely. The members of the 11 Wisconsin Tribes are somewhat dispersed -- most live on the designated reservations, many live near but off the reservations, and a few live farther away in quite different settings (e.g., in major urban areas or outside Wisconsin). We decided that the project should evaluate the nature of the risks faced by the Indians on and near the reservations, and not consider the potentially different sorts of risks facing other widely scattered individuals. The set of individuals covered by the study could not be defined much more precisely than this. Similarly, the geographic coverage of the study was left somewhat vague. The designated reservations are clearly the most important lands to the Wisconsin Tribes, but other lands have significance to them also:

- o Two Tribes (St. Croix and Winnebago) have a majority of their populations living not on reservations but in many communities dispersed throughout several Wisconsin counties; and
- o Several Tribes make extensive use of their treaty rights to fishing, hunting and gathering in the "Ceded Territories", comprising roughly the northern third of Wisconsin.

As a result, although the geographic focus of this study is largely on the designated reservations, some consideration is also given to conditions on the other lands of importance to the Tribes.

Diversity across the reservations

The intention of this project is to characterize the risks facing the members of the Wisconsin Tribes as a population distinct from the American culture as a whole. This is complicated by diversity across the reservations for the eleven Wisconsin Tribes. The reservations range from Oneida which is nearly completely altered from its historical natural state and adjoins the urban area of Green Bay, to several that remain largely untouched by development. The Red Cliff reservation consists mostly of islands in and shoreline on Lake Superior, reflecting environmental problems typical of the Lake in general. Other reservations, by contrast, are landlocked and exhibit different problems.

Because of geographic diversity and other differences across the reservations (degree of development, proximity to external sources of pollution, land use, and so forth), the pattern of environmental problems facing each Tribe is somewhat different. Our assessments and rankings are intended to reflect risks on the average across Wisconsin reservations. This averaging was rarely done in a precise, mathematical fashion. Instead, we used our judgment to determine

typical conditions across the reservations relating to an environmental problem, and assessed the risks resulting from these typical conditions. Where for some environmental problem one or another reservation differed quite sharply from the others, we ranked the problem to reflect typical conditions, but noted in this report the reservations that differ from the general pattern.

C. Ranking Methods

The most important task for us in this project was to review the data and risk analyses for each environmental problem, and to rank the problems in terms of their relative severity. Documentation of this data and analysis for each of the twenty-two problem areas is contained in Appendix B. Separate rankings were developed for: health risks, ecological risks, and social and economic damages. These separate rankings were not combined, so no explicit ranking of problems across all three types of risk was developed. However, there is some consistency in the separate rankings across the three types of risk, and rough conclusions can be drawn about the environmental problems that are generally of most importance for the Wisconsin Tribes.

The rankings ultimately depended on a mixture of data, analysis, and professional judgment by the work group members. The procedures used to develop each ranking were as follows.

Health risk ranking procedure

Separate rankings were developed for the cancer risks and the non-cancer risks caused by each of the twenty-two environmental problems. Both rankings were based largely on data regarding average risks to Tribe members, as data on the distribution of exposures across individuals was insufficient to generate any sense of the risks to maximally exposed individuals. The cancer risk estimates consisted largely of estimates of upper bound lifetime excess cancer risks from exposure to carcinogenic chemicals, derived by standard EPA procedures. The non-cancer risk estimates were derived mostly by comparing Native Americans' doses of toxic chemicals with established reference doses, ambient standards or other "virtually safe" levels. Some information on non-cancer risks came in the form of estimates of the number of cases of a health effect that were actually reported among Tribe members. The non-cancer ranking depends primarily on the relative number of individuals likely to suffer non-cancer impacts from each problem. Information on the relative severity of different non-cancer health effects associated with the environmental problems was considered, but as a less important factor in the ranking.

We combined the separate cancer and non-cancer rankings into a single, overall health risk ranking. Problems that were ranked similarly for cancer and non-cancer risks were kept in the same category for the combined ranking. For example, if a problem was ranked as high risk for both cancer and non-cancer, it was ranked high for combined effects also. We then discussed those problems that had dissimilar ranks for cancer and non-cancer and eventually developed a combined ordinal ranking by pairwise comparisons where needed.

Ecological risk ranking procedure

Separate rankings were developed for ecological risks to terrestrial and to aquatic ecosystems. In developing a ranking for each problem area, we reviewed the ecological stress agents associated with the problem area, and judged the degree of ecological risk they caused by considering several criteria:

- o The nature and intensity of the effect. This reflects the seriousness of the damage that occurs in ecosystems that are affected by the stress agents.
- o The scale of the effect. This reflects the areal extent of the ecosystems that suffer this effect.
- o The reversibility and time for the ecosystem to recover once the stress is removed.

We combined the separate rankings of risks to terrestrial and to aquatic ecosystems through a process of group discussion similar to that used to combine cancer and non-cancer health risks. Problems ranking similarly for terrestrial and aquatic ecosystems were kept in the same category for the combined ranking. Differing rankings were resolved through discussion.

Social and economic damages procedure

We followed a relatively simple procedure for ranking problems according to their social and economic damages. For each environmental problem, the damage categories listed on page 18 were reviewed and those in which impacts were expected were noted. For each damage category in which the problem had an impact, the impact was judged as being either clear and substantial or as uncertain and modest. The decisions about whether an environmental problem causes damage in a category and to what degree were based on two criteria:

- o What proportion of all the members of the Wisconsin Tribes suffer this damage from this environmental problem?
- o How great is this damage to the individuals who suffer it?

The first three of the nine damage categories were thought to be more important than the others, and they were given double weight in our evaluation. We used a simple scoring scheme to develop a preliminary relative ranking of environmental problems. A problem scored one point for each damage category in which it caused substantial impacts, and 1/2 point for each category in which it caused modest impacts. Points were doubled for the first three categories. Problems were first ranked in order of their total points. We then discussed the preliminary ranking and made several modifications to it based upon group consensus.

For each of the three types of risk, we developed ordinal rankings in descending order of severity for the twenty-two problems. Despite the limitations in data and analysis, we have

confidence that these ordinal rankings reflect the true relative risks from the problem areas for each type of risk. Because of uncertainties resulting from these limitations, we are more certain of the groupings of problems into higher, medium, and lower risk categories.

III. Project Results

This chapter recounts the conclusions developed by the project team in several areas. The environmental problems facing the eleven Wisconsin Tribes were ranked in order of their relative severity in terms of health risks, ecological risks, and social and economic damages. These rankings reflect the relative risks expected from the current level of environmental problems as they affect the Tribes. Using these rankings and the analysis that supports them, together with a very quick assessment of risk management factors, we also developed a different, more forward-looking ranking, in which problems were ranked according to their priority for development of risk-reduction and risk-prevention programs.

The rankings and our rationale for them are discussed briefly in this chapter. For more detailed information on how each environmental problem affects the Wisconsin Tribes, the reader is referred to the papers for each problem area in Appendix B.

This chapter also includes a discussion of the major data gaps identified by the project team in evaluating the environmental problems facing the Wisconsin Tribes and a review of the overall findings of this project in contrast to previous comparative risk studies of environmental problems affecting the broad population of Americans. It concludes with our recommendations and suggested next steps.

A. Health Risk Ranking

Perhaps surprisingly, given the generally isolated and relatively unpolluted character of the reservations, several environmental problems were found to pose substantial health risks. The problems ranked as posing high health risks were as follows:

Food contamination. Several studies from Wisconsin and Minnesota and a large amount of anecdotal evidence indicate that a very high proportion of Great Lakes area Indians' diets consists of locally harvested fish, game, fruit, grain and sweets. For example, about 90% of the Indians' consumption of meat, fish and poultry is estimated to derive from local harvesting of deer, bear, rabbits, walleye, northern pike, ducks and other species. Several of these species are at the top of terrestrial or aquatic food chains, and they drastically bioconcentrate certain pollutants found in their environment. Risk calculations combining data on Indian consumption rates for harvested fish and game with available data on concentrations of contaminants in local samples of the edible portions of these species yield substantial estimated health threats. Excess lifetime cancer risks are projected at about 4×10^{-3} (due primarily to PCBs, and secondarily to a variety of banned but persistent and bioaccumulative pesticides),¹ and hazard indices for non-

¹. An excess cancer risk of 4×10^{-3} means that an individual facing such a risk has an additional 4 chances in 1,000 of contracting cancer over a lifetime due to exposure to carcinogens from this source. For some other environmental problems where EPA has regulatory authority, the goal is often

cancer health effects (the ratio between the dose of a chemical received and its reference dose) substantially exceed unity for PCBs and for mercury.² These calculated risks represent those associated with only a fraction of the Indians' actual diet. Data were not available allowing calculation of the additional risks from locally harvested grains (e.g., wild rice), fruits (e.g., cranberries, for which there is some concern over pesticide applications) or sweets (e.g., maple sugar), or from non-local foods (e.g., commodities provided through Federal programs, for which there are some quality concerns).

Nonpoint source discharges to lakes and rivers. Nonpoint sources cause substantial health risks largely through air deposition of contaminants to surface waters, bioconcentration of the contaminants in aquatic species and in terrestrial species that feed on the aquatic species (e.g., ducks, otters), and heavy consumption by the Indians of the contaminated species. Health risks due to nonpoint sources are thus double-counted substantially with those from food consumption. Nonpoint source contamination of surface water contributes virtually no risks through the drinking water pathway, as all of the Wisconsin Tribes rely on ground water as their regular source of drinking water.

Substantial research has focused on the sources of mercury and PCBs in northern Wisconsin lakes. Most of the mercury in lakes derives from wet and dry deposition from the air, with a small amount from leaching from natural minerals. Point source contributions are minimal, as nearly all the lakes are isolated and unaffected by point sources. Contributions from point sources or contaminated sediments may be higher in Lake Superior (affecting the Bad River and Red Cliff Tribes), but are still insignificant relative to air deposition.

Mercury concentrations in the atmosphere and in precipitation are very low, deriving from long range transport, with about half being from natural sources (volcanoes and weathering of minerals) and about half from human sources (fossil fuel burning, industrial and municipal emissions). Mercury concentrations in the lake waters are also very low. However, fish (particularly older, larger predator fish such as muskies, walleyes and northern pike) concentrate the mercury that exists in their environment by factors of up to 1 million. Furthermore, acid deposition and the resulting acidification of Wisconsin lakes accelerates the biomethylation of

up pollution so that the average excess cancer rate for someone exposed to the problem is reduced to 1 chance in 1,000,000 (a cancer risk of 1×10^{-6}). The estimated cancer risk for Indian consumption of locally harvested fish and game is thus far higher than EPA often aims for in other programs.

². For non-cancer effects, when the ratio between the dose received of a chemical and its "reference dose" exceeds unity, the dose is above the level considered "safe" (based typically upon laboratory experiments with substantial margins of safety built in). Because of the safety margins built into reference dose calculations, a dose exceeding the reference dose cannot be said to be "unsafe" -- strictly speaking, such a dose exceeds the level at which safety is virtually certain. Exposure to a toxic substance resulting in a hazard index exceeding one may result in adverse health effects, with the likelihood of adverse health effects increasing as the hazard index increases. Hazard indices below one signify exposures that are nearly certain not to produce adverse health effects.

deposition and the resulting acidification of Wisconsin lakes accelerates the biomethylation of mercury into methylmercury -- a form much more easily assimilated by the tissues of freshwater fish. The Wisconsin Department of Natural Resources has been finding that about 1/3 of the lakes it tests in northern Wisconsin have game fish contaminated with mercury to a degree warranting issuing a fish consumption advisory for the lake.

PCBs show a somewhat similar pattern of sources and bioconcentration as does mercury. Air deposition is the primary source of the pollutant (for Lake Superior, 90% of PCB loadings come from air deposition), and larger, older predator fish show much higher concentrations. Several differences between PCBs and mercury are:

- o PCB concentrations in fish appear to have been declining over the past two decades or so, whereas mercury concentrations appear to be steady.
- o In some areas of the Great Lakes other than Lake Superior and isolated inland lakes, point sources are significant contributors of PCBs.
- o No information suggests that acid deposition plays any role in causing increased concentration of PCBs in fish.

Indoor air pollutants other than radon. Unfortunately, no data could be obtained on concentrations of indoor air pollutants other than radon in Tribal housing. However, we still felt confident in ranking this problem as a significant health risk. All comparative risk studies done elsewhere have used national data on indoor air pollution scaled to the area being studied. As in each of the other comparative risk studies, we found indoor air pollution to be one of the largest sources of both cancer and non-cancer health risks for the Tribes because of the significant sources and concentrations of air pollutants indoors (secondary cigarette smoke, combustion products, molds, allergens, solvents, asbestos, etc.) and the large fraction of time people spend indoors. In fact, several characteristics of Wisconsin Indian lifestyles make them even more subject to health risks from indoor air pollution than is the general population:

- o In most risk studies of indoor air pollution, environmental tobacco smoke ("passive smoking") is the single greatest source of risk. An Indian Health Service official estimates that perhaps 3/4 of the adult Wisconsin Indian population smokes, in contrast to 38% of adult Indians nationwide and 26% of all American adults.
- o Indian homes in Wisconsin are disproportionately heated (more than 50%) by wood burning, a form of heating that commonly produces much higher risks from indoor air pollution than electric, gas or oil heating. Use of kerosene and other unvented space heaters is also common in Indian housing.
- o The heating season is far longer in northern Wisconsin than is typical in the rest of the U.S., with houses closed up for more of the year.

- o With extensive recent construction, Indian homes are generally newer and probably more airtight than the average homes in the U.S., providing less ventilation and opportunity for exchange of cleaner outdoor air for polluted indoor air.

Indoor radon. Results of radon monitoring in over 1,000 Wisconsin Indian homes show a very high weighted average level of 5.8 pci/l, well above EPA's suggested action level for radon remediation of 4 pci/l. The estimated average individual excess lifetime cancer risk at this average concentration of radon in reservation homes is about 2.5×10^{-3} for non-smokers and is extremely high for smokers at 4.5×10^{-2} . Smoking greatly exacerbates cancer risk associated with radon exposure; on average, radon risk to smokers is about 15 times higher than risks to non-smokers. Lung cancer, which is caused by exposure to radon, is nearly always fatal to those contracting it. Radon concentrations appear to differ substantially across the reservations, being quite low in the northernmost reservations (Red Cliff and Bad River), and very high for the Menominee and Stockbridge-Munsee reservations. Although there may be some upward bias in these figures due to selective monitoring (homes suspected of having radon problems are often the first tested), we believe that these data are indicative of a very high cancer risk to Wisconsin Indians from indoor radon.

Drinking water contamination and Ground-water contamination. We ranked these two problems as causing high health risks, though clearly lower than the four problems already discussed above. The health risks from drinking water and ground water are overlapping and identical, as all of the Wisconsin Tribes' drinking water supplies are obtained from ground water and treatment of the ground water is minimal. The limited available data on drinking water quality for Wisconsin Tribal water supplies suggests likely problems with the following contaminants:

- o **Radionuclides.** Levels appear fairly high. Levels in many of the community systems and private wells are likely to exceed EPA's probable forthcoming national standards.³ Limited data on the relationship between radon in ground water and radon in indoor air suggests that an average of 5% of the radon in indoor air derives from groundwater. This relationship is dependent upon temperature and degree of agitation, among other factors. Most of this risk occurs as radon volatilizes from water, particularly during showering, and is subsequently inhaled.
- o **Microbiologicals.** Although the community water systems on the reservations rarely report a violation of the bacteriological MCLs, we are nevertheless concerned that the minimal treatment given to reservation water supplies combined with the widespread reports of septic system failures and poorly constructed

³. EPA has established or will establish national "Maximum Contaminant Level" (MCL) standards prescribing allowable levels of many different contaminants in drinking water.

shallow water wells could lead to frequent bacteriological contamination of drinking water.

- o Nitrates. Exceedances of the 10 mg/l MCL for nitrates are probably common on four of the reservations, judging from limited sampling data and the locations of agricultural production.

Evidence suggests that levels of other contaminants in Tribal drinking water -- pesticides, synthetic organics, VOCs and metals -- extremely rarely exceed health-based levels of concern. No data are available on concentrations of lead in drinking water.

We ranked several environmental problems in the next tier, as causing medium health risks. Highest among these was **Pesticides**. Pesticides in food were thought probably to cause modest risks, based largely on concentration data in fish and game and on previous national studies that found significant residues in many nationally marketed foods. Pesticides used in cranberry farming and forest management were also of some concern. **Municipal solid waste** was ranked as the next most serious problem, primarily because of sanitary problems associated with its disposal in scores of open dumps across the reservations. Uncontrolled burning, modestly contaminated leachate and runoff, and rats and other vermin are common at these sites. Other problem areas ranked as causing medium health risks were each responsible for modest risks in the vicinity of a few widely scattered sites: **Toxic air pollutants**, **Municipal wastewater discharges**, and **Abandoned hazardous waste sites**. A final problem area -- **Sulfur oxides and nitrogen oxides (including sulfates and acid deposition)** -- was ranked as causing medium health risks largely because of the role of acid deposition in increasing mercury concentrations in fish.

Ten other problems were ranked as causing low or no health risks to members of the Wisconsin Tribes. Most notable among them were several problems relating to criteria air pollutants -- **Ozone and carbon monoxide**, **Airborne lead**, and **Particulate matter**. Criteria air pollutants are often judged to cause very substantial health risks in many other areas of the country, but their levels on the Wisconsin reservations are well below health-based standards.

Table 4 summarizes our overall health risk ranking. Table 5 shows the separate rankings for cancer and non-cancer health risks that were combined into the overall ranking.

B. Ecological Risk Ranking

We believe that ecological conditions on and near the reservations are generally good. Most aquatic ecosystems are healthy, with naturally reproducing populations of game fish. Water quality in most rivers and lakes is good, with only a few lakes suffering nutrient enrichment problems and nearly all assessed stretches of rivers judged as supporting the designated uses set by the State of Wisconsin. Most of the original wetland acreage remains. Terrestrial ecosystems are also generally healthy, with most reservations remaining in a nearly natural, largely forested

Table 4: Combined Health Risks

Problem Area	Ranking	Comments
Food contamination	High	Very substantial cancer and non-cancer risks to average consumers of fish, large and small game, and poultry. Heavy consumers at even greater risk. No data on contaminants in local rice and fruit.
Nonpoint sources	High	Air deposition contributes mercury and PCBs, which bioconcentrate in fish and game. Substantial health risks (both cancer and non-cancer) for subsistence consumers.
Indoor air pollution	High	Lack of data, but conditions suggest high risks: high proportion of smokers, heavy use of wood stoves, and long heating season.
Indoor radon	High	Average level in homes monitored is well above EPA action level. Very high cancer risks. Levels differ sharply across reservations.
Drinking water contamination	High	Concentrations of radionuclides quite high, resulting in cancer risks. Poor septic systems near shallow wells may cause bacteriological problems.
Groundwater contamination	High	Naturally occurring radionuclides at high levels in groundwater, resulting in cancer risks. Bacteriological contamination likely from septic systems.
Pesticides	Medium	Some persistent now-banned pesticides have bioconcentrated in fish and game, causing moderate health risks to subsistence consumers. Also some concern about agricultural and silvicultural use.
Municipal solid waste	Medium	Solid waste typically disposed in open dumps in poor condition. Rodents, sanitation problems, and some groundwater contamination.
Air toxics	Medium	Limited data show low ambient concentrations. Impacts via air deposition are counted under other problems.
Municipal point sources	Medium	Few sources affect reservation waters, but treatment is minimal and some POTWs are in non-compliance.
Inactive hazardous waste	Medium	Fort Howard site may be responsible for modest air toxics risks. No other known important sites.
NOx, SOx, and acid deposition	Medium	Ambient concentrations low, but acid deposition appears to contribute to mercury concentration in game and fish.
Industrial point sources	Low	Almost no industrial sources affect reservation waters.
Storage tanks	Low	Relatively few tanks on reservations and no evidence of leaks affecting water supplies.
Airborne lead	Low	Ambient levels are far below standards.
Ozone and CO	Low	Ambient levels are below health-based standards.
Accidental releases	Low	No facilities with potential for large accidental releases. History of spills seems to consist of small incidents.
Particulate matter	Low	Ambient levels are well below health-based standards.
Physical degradation - aquatic	None	-
Physical degradation - terrestrial	None	-
Active hazardous waste	None	No active hazardous waste sites on reservations.
Industrial solid waste	None	No active industrial waste disposal.

Table 5: Cancer and Non-Cancer Health Risks

Non-Cancer		Cancer	
Problem Area	Ranking	Problem Area	Ranking
		Indoor radon	Very High
		Food contamination	Very High
		Indoor air pollution	Very High
Food contamination	High	Nonpoint sources	High
Nonpoint sources	High	Pesticides	High
Indoor air pollution	High	Groundwater contamination	High
		Drinking water contamination	High
Drinking water contamination	Medium	Municipal solid waste	Medium
Groundwater contamination	Medium	Air toxics	Medium
Municipal solid waste	Medium	Municipal point sources	Medium
SOx, NOx, and acid deposition	Medium	Inactive hazardous waste	Medium
		Industrial point sources	Medium
		Accidental releases	Medium
Municipal point sources	Low	Physical degradation - terrestrial	Low
Air toxics	Low	Physical degradation - aquatic	Low
Storage tanks	Low	Storage tanks	Low
Industrial point sources	Low		
Inactive hazardous waste	Low		
Ozone and CO	Low		
Particulate matter	Low		
Airborne lead	Low		
Accidental releases	Low		
Pesticides	Low		
Indoor radon	None	Particulate matter	None
Physical degradation - aquatic	None	SOx, NOx, and acid deposition	None
Physical degradation - terrestrial	None	Airborne lead	None
Active hazardous waste	None	Ozone and CO	None
Industrial solid waste	None	Active hazardous waste	None
		Industrial solid waste	None

condition. Timbering operations are carefully controlled, and have little negative impact. Small amounts of the reservations have been developed for housing, commercial, transportation or other purposes. Populations of most terrestrial species seem healthy and stable or growing, particularly deer, bear and rabbits.

There are, however, indications of some serious ecological problems. Populations of a few predator species (eagles, mink, osprey, otters, lake trout) have declined very substantially from historical levels, because of either toxic substances (e.g., eggshell thinning in birds resulting from accumulations of pesticides), competition from introduced species (e.g., lamprey eels preying on lake trout), reduction in suitable habitat throughout the region, and/or overharvesting. Although game fish are abundant and healthy in most lakes, their numbers are reduced, probably due to subtle changes in habitat, fishing pressure, and deterioration in water quality. Some water bodies have undergone massive hydrologic disruptions with construction of dams, flood control projects, and channelization. Two reservations have been extensively transformed by farming. Acid deposition appears to contribute to some forest decline, and to acidification of surface waters.

In sum, then, ecological conditions on and near the reservations are quite good by comparison with most of the remainder of the U.S.. However, conditions now do not match those of a century or more ago when the U.S. made its treaty commitments with the Tribes.

We ranked the following three problems as causing relatively higher ecological risks.

Nonpoint source discharges to lakes and rivers was ranked as causing the greatest relative risks. Perhaps surprisingly, the high concentrations of PCBs, mercury, and other toxic substances (which derive largely from nonpoint sources) in large fish in reservation areas do not seem to be symptomatic of extreme ecological damage. Extensive studies of fish populations in the ceded territories have found:

- o Populations of walleye, muskie and northern pike appear lower than decades ago, but have been stable in recent years despite increasing fishing pressure. Each of these fish is still found in most of its historical range.
- o Deformities, lesions and tumors (typical signs of substantial stress to fish populations from toxic substances) do not appear to be common.

Nevertheless, populations of plant-eating fish (e.g., perch, whitefish) are clearly generally healthier than populations of predator fish that bioconcentrate toxic substances to a greater degree. Non-fish species that consume large amounts of fish (e.g., bald eagles, cormorants, terns, mink, otter) also seem to be adversely affected by toxic substances, particularly PCBs. In addition to toxic substances, nonpoint sources are also responsible for nutrient enrichment and eutrophication of some lakes (primarily from septic tanks and fertilizer runoff) and siltation of some areas of fish habitat.

Sulfur oxides and nitrogen oxides (including sulfates and acid deposition) was ranked as causing the second most ecological damage. Precipitation in northern Wisconsin is moderately acidic at a pH of about 4.5 to 5.0. Acidity seems to be decreasing in recent years with decreasing emissions of SO₂. Studies have found moderate ecological changes from acid deposition in Northern Wisconsin lakes, some changes in forests, and no impacts yet on streams.

A 1988 survey found about 6% of Northern Wisconsin's lake area to be acidified (pH of less than 6.0), which is a lower percentage than in many other areas of the country. At this level of acidity some aquatic species are typically lost, although a diverse and healthy aquatic ecosystem is still probable. All aquatic life is likely to be lost at a pH of about 4.2; but none of Wisconsin's lakes approaches this level. Acid deposition to Wisconsin lakes facilitates uptake of mercury by fish, and this in turn has adversely affected the health and reproductive success of fish-eaters such as eagles, osprey, loons and furbearers. The acid neutralizing capacity of Wisconsin's lakes is fairly low, with 40% classified as extremely sensitive to acid deposition.

Studies of Wisconsin forests found about 1% of the sugar maples to be experiencing decline or to be dead as a result probably of acid deposition. 50 - 70% of the white pines displayed premature needle loss due to a combination of acid deposition and ozone.

Physical degradation of water and wetland habitats was ranked as the third most serious ecological problem. Maps drawn from aerial photographs show a substantial proportion of lake and river shorelines within the reservations to be developed with low density resorts, cottages, cabins, and docks. For several decades, some of the Tribes were actively seeking revenue by leasing or selling their most desirable waterfront lands to outsiders. These numerous small developments have resulted in fill and alteration of wetlands and shoreline spawning areas, reduction of shoreline fish cover, modification of water flows, and increased siltation. Some water bodies in reservations have been sharply altered by off-reservation hydropower dams, flood control projects and channelization. The Lac Court Oreilles Reservation, for example, lost much of its historical wild rice acreage because of an off-site dam and flooding.

Other environmental problems were ranked as causing lesser ecological risks to the reservations and nearby areas. We ranked **Physical degradation of terrestrial habitats** as causing medium risks. On most reservations, land development activities (housing, transportation, timbering, agriculture, etc.) are at a sufficiently limited scale to cause no discernable impact to terrestrial ecosystems or species. For several reservations (particularly Oneida and St. Croix), though, agricultural and other development has proceeded far enough to change substantially the character of the ecosystems. **Pesticides** was also ranked as causing medium ecological risks, primarily because of their substantial historical impacts on eagles and fish-eating birds. There was also some concern about the unknown, but possibly significant impacts of pesticide use for cranberry production, timber management, and rights-of-way clearing. Finally, **Municipal solid waste sites** was ranked as causing medium risks due to their impacts on plant and animal communities in the immediate vicinity of the many scattered open dump sites.

Among the problems ranked as causing low or no ecological risks, several deserve

mention. **Municipal wastewater discharges** and **Industrial wastewater discharges** were ranked low because there are very few of them that actually affect reservation waters. There has been only one **Accidental release** with a documented ecological impact (the rupture of an oil pipeline traversing the Bad River), and the impact was transitory. Only one confirmed **Hazardous waste site with past disposal** exists on or near the reservations (the Fort Howard sludge lagoon), and it appears to have no ecological impact.

Table 6 summarizes our overall ranking of ecological risks. Table 7 shows the separate rankings for risks to aquatic and terrestrial ecosystems that were combined into the overall ranking.

C. Social and Economic Damages Ranking

As previously described (see page 18), a wide variety of different impacts were evaluated under the topic of social and economic damages, ranging from some closely related to health risks (e.g., the costs of health care and lost productivity associated with adverse health impacts from pollution) to others closely related to ecological risks (e.g., the reduction in commercial and subsistence opportunities when a resource such as a fishery is damaged) and to others not closely related to other varieties of risk (e.g., cultural, religious or aesthetic damages). Although nine different categories of damages were considered, our ranking of social and economic damages gave greater weight to three:

- o Diminution of cultural and religious values;
- o Damage to subsistence activities; and
- o Damage to natural resources in commercial use.

Nonpoint source discharges to lakes and rivers was ranked as the most important source of social and economic damages. The designation of an ever-expanding number of the Tribes' traditional fishing lakes as subject to fish consumption advisories is having a substantial adverse cultural impact. Spearing of fish and sharing the catch among Tribe members has been a traditional activity for centuries, but increasing numbers of Indians are having difficulty participating wholeheartedly in these activities now. Many Indians are worried about limiting their fish consumption, about where the fish they are given have been obtained, and about the number of lakes being suggested to be off-limits. Nonpoint sources are responsible for most of these impacts.

Physical degradation of water and wetland habitats was ranked as the second most important source of social and economic damages. Flooding from hydropower dams and siltation and other hydrological changes have sharply reduced or eliminated the wild rice beds in several reservations. Resort use of prime waterfront properties by non-Indian outsiders, while welcomed as a source of revenue in the past, is now regarded as an aesthetic problem and a cultural affront.

Table 6: Combined Ecological Risks

Problem Area	Ranking	Comments
Nonpoint sources	High	Siltation, eutrophication, and air deposition of toxics all cause damage to aquatic communities.
SOx, NOx, and acid deposition	High	Modestly acidic rain has acidified some lakes and damaged some forest species. No apparent impact on streams.
Physical degradation - aquatic	High	Moderate amounts of shoreline development have changed aquatic habitats. Some waters have been affected by major dams or other projects.
Physical degradation - terrestrial	Medium	Limited development on most reservations causes little damage. Agriculture and other development have substantially changed the character of several reservations.
Pesticides	Medium	Some persistent, now banned, pesticides appear responsible for decline in several species -- eagles, osprey, etc.
Municipal solid waste	Medium	Very poor conditions at many scattered open dumps cause local ecological impacts.
Municipal point sources	Low	Few sources affect reservation waters. Minimal discharge of toxics.
Groundwater contamination	Low	Relatively few instances of contaminated groundwater. Impacts from discharge to surface are probably minimal.
Storage tanks	Low	Few tanks and no evidence of ecological damage from leaks.
Accidental releases	Low	No facilities with potential for large releases. Small spills that have been reported caused little damage.
Air toxics	Low	Low ambient concentrations and no evidence of ecological impacts.
Inactive hazardous waste	Low	Little apparent ecological impact from Fort Howard site. No other known significant sites.
Industrial point sources	Low	Almost no industrial sources affect reservation waters.
Industrial solid waste	Low	No active industrial waste disposal.
Active hazardous waste	None	No active hazardous waste sites on reservations.
Indoor radon	None	-
Indoor air pollution	None	-
Ozone and CO	None	Ambient concentrations are below levels at which significant damages can be expected.
Particulate matter	None	Ambient levels are very low.
Food contamination	None	-
Airborne lead	None	Ambient levels are very low.
Drinking water contamination	None	-

Table 7: Aquatic and Terrestrial Ecosystem Risks

Aquatic		Terrestrial	
Problem Area	Ranking	Problem Area	Ranking
Nonpoint sources	High		
SOx, NOx, and acid deposition	High		
Physical degradation - aquatic	Medium	Physical degradation - terrestrial	Medium
Municipal solid waste	Medium	SOx, NOx, and acid deposition	Medium
		Pesticides	Medium
Industrial point sources	Low	Nonpoint sources	Low
Municipal point sources	Low	Municipal solid waste	Low
Pesticides	Low	Air toxics	Low
Groundwater contamination	Low	Accidental releases	Low
Physical degradation - terrestrial	Low	Groundwater contamination	Low
Storage tanks	Low	Storage tanks	Low
Inactive hazardous waste	Low	Municipal point sources	Low
Accidental releases	Low	Physical degradation - aquatic	Low
		Industrial point sources	Low
		Inactive hazardous waste	Low
		Industrial solid waste	Low
Drinking water contamination	None	Indoor radon	None
Indoor air pollution	None	Indoor air pollution	None
Indoor radon	None	Ozone and CO	None
Active hazardous waste	None	Food contamination	None
Industrial solid waste	None	Airborne lead	None
Air toxics	None	Active hazardous waste	None
Ozone and CO	None	Particulate matter	None
Food contamination	None	Drinking water	None
Airborne lead	None		
Particulate matter	None		

Food contamination was ranked as causing high risks for reasons similar to those causing nonpoint sources to be ranked as causing the greatest social and economic damages. So was **Sulfur oxides and nitrogen oxides (including sulfates and acid deposition)**. Acid deposition also poses a further long term threat to the forests that define the character of most of the reservations.

Physical degradation of terrestrial habitats was also ranked as causing high risks. Two Tribes whose culture has been largely focused around forested lands now have reservations that have become mostly agricultural (Oneida and St. Croix) in character. On most reservations, even the low amount of commercial development that occurs (particularly the gaming establishments that bring in large numbers of visitors) is sufficient to create a clash with traditional Indian culture. Development also appears to be a significant factor in the decline of mink and other furbearing animals that supported substantial commercial trapping activities several decades ago. Trapping has now declined to minimal levels.

The final problem area ranked as causing high social and economic damages was **Hazardous waste sites with past disposal**. Although there is only one such site known to be on or adjacent to the reservations -- the Fort Howard paper company sludge lagoon -- we considered any such site to be a major damage to the cultural values associated with respect for the Earth.

The problems ranked as causing medium social and economic damages introduce several additional noteworthy types of damages. **Municipal wastewater discharges, Accidental releases, and Municipal solid waste sites** all represent very poorly controlled uses of the reservation environment for waste disposal in what is viewed as an unthinking, cavalier manner that the Indians find culturally offensive. **Pesticides** are largely responsible for the reduced populations of eagles, a bird of particular religious and cultural significance to the Indians. **Indoor radon and Indoor air pollution other than radon** are both likely to produce high health care costs and losses in productivity among those who are stricken with the diseases they cause. **Drinking water contamination and Ground-water contamination** involving high iron concentrations in many reservation water supplies cause poor tasting water and aesthetic problems, or necessitate water treatment expenses to avoid the aesthetic problems.

Table 8 summarizes our overall ranking of social and economic damages.

D. Data Gaps

In the course of our evaluation of the risks posed to the Wisconsin Tribes from environmental problems, we found a number of important data gaps. Improved knowledge in these areas would contribute substantially to better understanding and more efficient management of Indian environmental problems. The data gaps include:

Table 8: Social and Economic Damages

Problem Area	Ranking	Comments
Nonpoint sources	High	Contamination of lake fish by mercury and PCBs from nonpoint sources is harming cultural values and subsistence fishing.
Physical degradation -- aquatic	High	Wild rice beds in several reservations are sharply reduced by flooding from dams and other hydrologic changes. Resort use of many waterfront areas by non-Native Americans is an aesthetic and cultural problem.
Food contamination	High	High levels of contaminants in local fish and game entail health care costs and require Native Americans to reconsider traditional fishing and hunting practices.
Physical degradation -- terrestrial	High	Land development has caused cultural change in many areas: several reservations are largely open land rather than forested, trapping of fur-bearing animals has declined sharply, and gaming establishments and other tourist attractions bring outsiders.
Inactive hazardous waste	High	Abandoned hazardous waste sites regarded as a major cultural insult to the Tribes' respect for the Earth.
SO _x , NO _x , and acid deposition	High	Acid deposition contributes to fish contamination problems. Long term threat to forestry also.
Municipal point sources	Medium	Poor quality treatment plants represent unsatisfactory exploitation of reservation waters. Aesthetic problems.
Accidental releases	Medium	Entail modest clean-up costs. Accidents often result from transport of hazardous substances across reservations by outsiders.
Pesticides	Medium	Largely responsible for decline of eagles, osprey, and other species of cultural importance.
Indoor radon	Medium	Likely to cause substantial costs for medical care and lost productivity for those with cancer. Mitigation costs also.
Indoor air pollution	Medium	Likely to cause substantial costs for medical care and lost productivity of those suffering health impacts.
Drinking water contamination	Medium	Some health care costs. High iron levels cause aesthetic problems, cleaning, and/or water treatment expenses.
Groundwater contamination	Medium	Some health care costs. High iron levels cause aesthetic problems, cleaning, and/or water treatment expenses.
Municipal solid waste	Medium	Very poor conditions at open dumps cause aesthetic problems. Use of land for indiscriminate waste disposal is culturally offensive.
Ozone and CO	Low	Low concentrations on reservations. Potential long-run damage to commercial timber and crops.
Industrial point sources	Low	Very few sources affect reservations.
Storage tanks	Low	Few tanks, typically very local impacts only when they leak.
Industrial solid waste	Low	No sites.
Particulate matter	Low	Concentrations on reservations very low.
Air toxics	Low	No significant problems.
Airborne lead	Low	Concentrations very low.
Active hazardous waste	Low	No active hazardous waste sites on reservations.

Basic environmental monitoring information. Relatively little information exists specific to the reservations themselves on concentrations of environmental pollutants in air, surface water, ground water, drinking water, or food. Much of the monitoring information we obtained for this project derived from locations outside the reservations that we judged were likely to exhibit conditions similar to the reservations. This extrapolated information is likely to be generally representative of the reservations, but monitoring of the reservations themselves is likely to be valuable in uncovering unexpected hot spots or anomalies.

Comprehensive ecological characterization. Information on the health of the ecosystems in and near the reservations is widely scattered and anecdotal. Substantial information exists on some species (e.g., walleyes, eagles) and on some problems (e.g., mercury in lakes, old from pollution) to others closely related to ecological risks (e.g., the reduction in commercial and bioaccumulative pesticides), but there is insufficient linkage of this information into a systematic understanding of broad ecological trends. For example, the populations of minks and other furbearing species appear to have declined substantially in recent decades, a change with important ecological and cultural implications. We found no general evaluation of the reasons for this population decline -- whether it be excessive trapping, the sensitivity of these species to even small amounts of human development, some adverse change in an element of their habitat, toxic substances in their food supply, or other factors. A more systematic understanding is needed of ecological trends and their relationship to environmental problems.

Indoor air pollution. All previous comparative risk studies have identified indoor air pollution as one of the most serious environmental threats to the health of the general population. No specific data were available on concentrations of air pollutants in Wisconsin Indian homes, but several characteristics of the Indians' lifestyle led us to suspect that risks to Indians were likely to be even higher than to the general population. Studies to characterize the extent and severity of indoor air pollution in Indian homes and to pinpoint its causes are needed to better characterize this high risk.

Lead. Similarly, lead has been found to be a significant source of health and social and economic damages in most studies of other populations. No data were available for the Wisconsin Tribes on lead concentrations in blood or drinking water. While there is no suggestion that the Tribes are likely to have worse lead problems than the general population, some sampling is needed to evaluate the magnitude among Native Americans of this often substantial problem.

Contamination of food other than fish and game. Sampling of local fish and game suggests substantial risks to the average Wisconsin Indians. No data were available on contaminants in other local foodstuffs relied upon heavily by the Indians for subsistence -- wild rice, seasonal vegetables, cranberries and other berries, maple sugar, etc.. These plants may or may not concentrate contaminants from their environment and contribute further to the doses of toxic substances in the Indian diets. Similarly, no information is available on the quality of non-local foods consumed by the Indians, particularly the Federally-supplied commodities. Sampling for pesticides, metals, synthetic organics and other toxic substances in the remainder of the Indian diet beyond local fish and game would allow for a more complete characterization of the risks

from food contamination.

E. Need for Environmental Protection Infrastructure

The risk rankings we developed reflect the risks that result from current environmental problems facing the Wisconsin Tribes. The Tribes, however, feel particularly vulnerable to worsening environmental problems in the future.

The isolation of the reservations has protected them from external environmental threats to some degree so far. However, as development outside the reservations continues, pollutants will flow into the reservations. The Tribes feel powerless to influence the nature and impacts of this development. Conscious choices by the Tribes to limit industrial development and resource extraction within the reservations have also helped to minimize environmental problems. Such choices are becoming harder to maintain as needs for economic development intensify.

Juxtaposed against likely growing external and internal environmental threats is the nearly complete lack of administrative or physical infrastructure with which the Tribes can manage environmental problems from sources either within or outside of the reservations. For example, Tribal environmental staffs are minimal; there are few Tribal laboratories and minimal environmental monitoring has occurred; there are no air or water quality standards enforced for the reservations; and many drinking water treatment, sewage treatment and waste disposal facilities are substandard.

In addition, the Tribes contend that environmental quality may mean more to them than to the mainstream American culture. The Tribes place high value on their traditional harmonious relationship with their ecosystem. They have subsisted for centuries within the carrying capacity of local ecosystems on the physical and biological resources provided by their lands. But the Indians are now limited in pursuing their traditional activities to the small vestigial reservation areas and treaty-specified hunting and fishing areas. These areas must remain undamaged for centuries into the future if the Tribes are to maintain their ancestral values.

Comparative risk projects can provide an analytical foundation on which efforts to reduce environmental risks are based. But the comparative risk approach evaluates current, demonstrated environmental risks. Comparative risk alone cannot devote sufficient attention to the need to protect the land and Indian culture from risks for the very long term future and the vulnerability of the small amount of reservation land to growing risks in the future. It is very important to build the capacity for Tribes to protect their environment both from current risks (where most of the attention in this project was devoted) and from potential future risks (where less attention was focused). We thus developed some broad recommendations for environmental protection priorities for the Tribes to respond to the combination of current and potential future problems. The following is a list of the environmental problems facing the Wisconsin Tribes for which infrastructure development (both administrative and physical) is most necessary:

Highest priority areas for infrastructure development:

- Protection of surface water quality (from nonpoint sources, and industrial and municipal point sources)
- Protection of groundwater and drinking water quality
- Municipal solid waste
- Aquatic and terrestrial habitat alteration
- Radon
- Pesticides
- Food contamination (both subsistence fish and game, and USDA commodities)

Risks could be substantially lowered, particularly in these areas, if Tribes had the appropriate capacity to manage environmental problems. The Tribes need capability themselves - in terms of both knowledge and resources -- and support and cooperation from other organizations such as EPA and the State. The Tribes must be able to understand, manage and protect their reservation environments directly, and must be able to influence the policy decisions made off the reservations that can have major impacts on the reservations and surrounding lands on which Indian subsistence rights are retained.

In recommending these areas for risk reduction efforts, we considered the rankings for each type of risk together with the analysis that supports those rankings. The analysis shows the causes of the risk -- key information to developing effective solutions. In developing priorities for responding to risks, we also considered a variety of factors bearing on the likely degree to which risks in each area can be managed. We call these "risk management factors"; they include cost-effectiveness, technical feasibility, political and organizational feasibility, legislative authority and so forth. In developing this list of priorities, we considered all the information on current and future risks contained in the analysis together with a very quick assessment of the risk management factors.

The analysis documented in this report is a crucial first step in identifying where investments in capacity-building can be most important in reducing risks. Additional analysis and discussion of the risk management considerations will lead to the most effective and successful solutions.

F. Comparing the Results with Other Studies

We ranked several environmental problems as consistently posing high risks across each of the three different types of impacts. These appear to be the most significant environmental problems affecting the Tribes overall:

- o Nonpoint source discharges
- o Food contamination

- o Acid deposition
- o Physical degradation of aquatic habitats

The first three of these problems interrelate through long-range air deposition of PCBs, mercury, and pesticides onto surface waters, and bioaccumulation of these toxic substances through aquatic and terrestrial food chains in a process partly exacerbated by acid deposition. Damages then occur to the health of Native American subsistence consumers of local fish and game, to aquatic and terrestrial ecosystems, and to Native American cultural traditions and commercial opportunities. Physical degradation of aquatic habitats involves a different set of issues, causing primarily ecological and cultural damages.

In addition to these problems that we ranked as causing substantial risks across more than one category of damage, we ranked several other important problems as causing high risks in only one category of damage:

- o Indoor air pollution and indoor radon are responsible for serious health risks;
- o Physical degradation of terrestrial habitats causes significant social and economic damages; and
- o Hazardous waste sites with past disposal are also responsible for large social and economic damages.

These rankings of environmental problems for the Wisconsin Tribes are quite different than those developed in other comparative risk studies of the general population in a variety of geographic areas. The most significant contrasts with other studies are discussed below.⁴

Food contamination from environmental sources (except for residues of agricultural pesticides) has never been noted as a top problem in other projects. For the Wisconsin Tribes, food contamination clearly causes serious health and social and economic damages even without considering a contribution to risk from pesticide residues on agricultural crops. The high risks from this problem to the Wisconsin Tribes result from the combination of an environment in which, though it is relatively pristine, large numbers of top-of-food-chain predators efficiently bioconcentrate toxic chemicals and a culture that highly values subsistence harvesting activities.

Problems deriving from industrial activity rank unusually low on the reservations, but often rank high in other studies. In the Region 5 comparative risk study, for example, accidental releases, toxic air pollutants, abandoned hazardous waste sites, and industrial point source

⁴ The rankings of the relative risks to human health, ecosystems, and economic and social systems for the Wisconsin Tribes from different environmental problems are compared here to the relative rankings for these same problems as developed in other comparative risk studies. We did not attempt to compare any absolute level of risk found across different studies.

discharges all ranked far higher than they did for the Wisconsin Tribes. There is simply very little industrial activity on the reservations or in their immediate vicinity.

Problems deriving from long range transport of pollutants rank unusually high on the reservations. To generalize very broadly, most comparative risk projects have found that the most serious risks usually derive from sources within or near the study area. While nearby sources are important for some environmental problems affecting the Tribes, the more serious problems facing the reservations derive largely from outside the reservations. This has important implications for risk management, since extensive cooperation between the Tribes and other governmental jurisdictions is necessary to address distant sources of contamination.

Most studies find that criteria air pollutants pose high health, ecological and economic risks. On the reservations, by contrast, we found that they pose rather low risks (with the exception of acid deposition).

We ranked municipal solid waste sites as causing medium health, ecological and social and economic damages. These rankings contrast with typical findings that municipal solid waste sites pose low risks. The higher ranking for the Tribes is due to the very poor practices in effect at the many household waste dump sites on the reservations.

Many comparative risk studies have found that point sources of water pollution (municipal and industrial) pose at least medium ecological and economic risks. For water bodies on the reservations, though, there are very few point sources with any potential impact at all. Most such point sources are small and in compliance with their state and Federal permit limits, and both municipal and industrial point sources pose generally low risks to the Wisconsin Tribes.

Several factors explain these substantial differences between the ranking of environmental risks to the Wisconsin Tribes and the rankings obtained in other studies of the population at large. First is the isolated, rural, and generally undeveloped nature of the reservations. Most comparative risk studies have focused on areas where the bulk of the population lives in developed, industrialized urban areas. A second factor is the general choice made by the Tribes to pursue activities on the reservations that are in harmony with the environment. The Tribes are motivated to maintain their lands such that their environment will yield a sustained flow of goods and services. They have generally avoided industrial development and other activities that may seriously damage the environment. The final difference involves the lifestyle and culture of the Wisconsin Tribes. Heavy reliance on subsistence hunting, fishing, and gathering makes the Tribes vulnerable to whatever pollutants concentrate in local food sources. The cultural importance of certain features in the Indians environment (e.g., eagles, wild rice, mink) means that the Indians are much more affected by environmental problems that influence these specific features than is the general population.

We believe that the very substantial differences between the pattern of environmental risks facing the Wisconsin Tribes and that facing the general population suggest that the Indians need somewhat different environmental programs than does the population at large. Priorities for

environmental action for the Indian Tribes should differ from those for the general population, as a reflection of the differing risks facing each group. The understanding provided by this project of the relative environmental risks facing the Tribes, together with consideration of risk management factors, will help in developing more effective environmental programs to protect the unique people and resources of the Wisconsin Tribes.

Other Tribes in other areas, as well as other minority groups, may face other patterns of environmental risks that differ from those faced by the population as a whole. The comparative risk process could be of significant value to other groups in determining more clearly what their specific environmental protection needs may be.

G. Project Recommendations

After completing the analysis and risk evaluations, we have two recommendations for the use of this project's methods and results: 1) use the analysis and rankings to help guide risk management activities both on the reservations and in EPA and other Federal agency programs; and 2) use the adapted comparative risk methodology in future comparative risk projects with other Tribes.

This comparative risk project has assembled a significant amount of data that has been combined with professional judgement in a consistent analytical framework to evaluate the risks that affect the Wisconsin Tribes and the environment in which they live and on which they depend. The project has produced valuable information and insights on these risks and possible ways to prevent, control, and reduce them. We recommend that these analytical results be used on the reservations to target and address current (and potential future) high risks. We also recommend that the analysis and rankings be used in EPA's programs to help guide their priority-setting and program activities. Discussions with other Federal and State agencies can begin a process where these project results are used to help guide actions in their programs as well.

The comparative risk framework has been used successfully by EPA and other state and local governments to evaluate and rank risks that are used to set priorities for action. This project has adapted the framework to more accurately assess the risks faced by the Native Americans and their environment by considering the different pathways and exposure routes affecting the health of the Tribes and their cultural and economic values that are affected by environmental problems. We believe that these methods have been very useful in evaluating the risks faced by the Tribes and will provide valuable insights to improve risk management activities. We recommend that these adapted methods be used to assess risks for other Native American Tribes to determine how risks differ on their reservations and empower them to more effectively address those risks.

H. Suggested Next Steps

Most of our effort in this project has centered on risk assessment -- evaluating the environmental problems facing the Wisconsin Tribes and ranking them in terms of their relative severity. In conducting this process we have gained a better understanding of these problems and some broad insights on how to address them, and have identified areas where improved information can significantly increase our ability to understand, evaluate, and ultimately address the Tribes' environmental risks.

In several areas, a better understanding of the problem would contribute significantly to targeting remedial programs at key portions of the problem:

- o More detailed information on the ecology of the reservation areas and how it is influenced by various habitat altering activities;
- o Studies to characterize the extent and severity of indoor air pollution in Native American homes and commercial structures; and
- o Sampling to determine the quality of the remainder of the Indian diet beyond local fish and game.

In determining what should ultimately be done to address risks, one cannot simply apply all resources to the top-ranked problems, or even to proportion the resources according to the rankings with somewhat more resources going to the top-ranked problems than to the lower-ranked problems. The rankings of residual risk alone will not tell you how resources can be used most effectively to reduce those risks. But the rankings, together with the analysis that supports them, will provide insights into the causes of the risk and will serve as a very powerful tool for developing effective and efficient solutions for addressing those risks. The risk management factors -- cost-effectiveness, technical feasibility, political and organizational feasibility, and legislative authority⁵ -- can help you determine which proposed solutions, with what implementation plan and on what time schedule, are best.

Some environmental problems clearly pose high risks to the Tribes now: the interrelated problems of food contamination, nonpoint sources and acid deposition; habitat alteration; indoor air pollution, and radon. Comprehensive programs should be developed to address these specific problems, beginning with the existing measures that are already under way.

For other environmental problems that have been found to be less serious, the lower level of many of the other environmental risks on the reservations is due to the low density of risk-

⁵ Lack of legislative authority is not always an insurmountable barrier to implementing necessary solutions. There may be non-regulatory solutions, such as education or economic incentives, that can be implemented, or an agency can work with legislative bodies to implement needed legislation.

producing activities on or near the reservations, and not to the fact that risk-producing activities are well managed. Infrastructure for managing environmental risks on the reservations -- programs for environmental research, monitoring, standard setting and enforcement, as well as facilities for sewage treatment, solid waste disposal, drinking water treatment and the like -- is very limited. The current modest programmatic and physical infrastructure could easily be overwhelmed by future growth of population and economic activity. The Tribes need both better environmental management programs and improved environmental protection facilities to keep risks from growing in the future. At a minimum, the Tribes need adequate environmental protection staffs, a basic monitoring program (at least for the larger reservations), environmental quality standards that reflect Tribal designated uses, credible implementation and enforcement programs, and support for constructing and operating appropriate waste management facilities. An environmental education program for the reservations and surrounding communities can help generate public support for building the necessary Tribal environmental protection capacity.

Many of the risks faced by the Tribes derive from activities outside the reservation rather than on the reservations. The Tribes have very little ability to affect decisions on these activities and protect their interests. Native Americans should be able to participate in environmental decisions affecting them (affecting both the reservations themselves and the ceded territories) made at the State, regional, and national levels. The Federal trust responsibility should be fully upheld in the environmental area. This may include measures to reflect the Tribes' interests on issues such as: re-licensing decisions for hydroelectric projects, other major developments needing Federal and State approvals, decisions on State designated uses for land and waters in the ceded territory, and State and Federal environmental budget priorities.

Even if these steps can be accomplished -- if Tribes develop effective environmental management programs for the reservations, and if they participate in and have their interests represented in decisions explicitly affecting their environment -- there will still be a residual of environmental problems stemming from long range transport of pollutants from diffuse sources. Broad scale acid deposition and air deposition of PCBs and mercury appear to be such issues. To address these problems, we believe that all elements of society -- governments, industry, and households -- can benefit from use of pollution prevention as the solution of first choice, together with pollution control, regulatory, economic incentives, or other actions as appropriate, to both prevent and reduce risk from environmental problems. American society at large can learn from the Native Americans' credo of living in harmony and partnership with the environment.

Appendix A: Definitions of Problem Areas Considered for Ranking

1. Industrial Wastewater Discharges to Lakes and Rivers

These are sources of pollution that discharge effluents into surface waters through discrete conveyances such as pipes or outfalls. This problem area does not include publicly and privately owned municipal wastewater discharges. Pollutants of concern include total suspended solids; BOD; toxic organics, including phthalates and phenols; toxic inorganics such as heavy metals; and thermal pollution. Typical sources of discharge include metal finishing, pulp and paper processing, and iron and steel production. Facilities requiring permits under the National Pollution Discharge Elimination System (NPDES) fall under this problem area.

2. Municipal Wastewater Discharges to Lakes and Rivers

This problem area includes all constituents of the outfalls of publicly and privately owned municipal wastewater treatment facilities. Both municipal sewage treatment outfalls and industrial discharges that flow through publicly operated treatment works are included in this problem area. Major contaminants include all those found under Industrial Wastewater Discharges to Lakes and Rivers, plus ammonia, chlorination products, and nutrients. Combined Sewer Overflows (CSO's) are included in this problem area.

3. Nonpoint Source Discharges to Lakes and Rivers

Nonpoint Source Discharges include pollutants that reach surface waters through sources other than discrete conveyances for effluents. This includes runoff from agricultural, urban, industrial, silvicultural, or undisturbed land. Possible pollutants are quite varied, including most of the constituents of the point source discharges to surface waters. Storm water carries a large amount of solids, nutrients, and toxics. Other sources included in this problem area are: surface discharge of septic tanks, releases from contaminated in-place sediments, air deposition of pollutants (except for acids), and mine drainage. Pollutants not included in this problem area are those from acid deposition, solid waste disposal, hazardous waste sites (RCRA and CERCLA), and physical impacts from discharges of dredge and fill material.

4. Aggregated Public and Private Drinking Water Supplies

As drinking water arrives at the tap, it may contain a wide variety of contaminants from both natural and man-made sources, and point and nonpoint sources. Since many of the contaminants can be traced to other problem areas, Drinking Water risk evaluation will involve much double-counting with those other problem areas (Industrial Wastewater Discharges, POTW Discharges, Nonpoint Source Discharges, Storage Tanks, hazardous and non-hazardous waste problem areas, etc). Drinking Water is included as a problem area because remediation/treatment options can occur either at the source of contamination (the other problem areas) or at the delivery system of the drinking water (treatment or switch to alternative supplies). Drinking Water

includes both delivery systems that serve 25 or more people and are therefore covered by the Safe Drinking Water Act, and those which serve fewer than 25 people and are not so covered. Pollutants of concern include disinfection byproducts, pesticides, inorganics (such as heavy metals), radionuclides, toxic organics, fluoride from natural sources, and microbiological contaminants.

5. Aggregated Groundwater Contamination

All forms of groundwater pollution, including sources not counted in other problem areas, compose this problem area. These include fertilizer leaching, septic systems, road salt, all injection wells, nonwaste material stockpiles, pipelines, and irrigation practices. The list of possible contaminants is extensive and includes nutrients, toxic inorganics and organics, oil and petroleum products, and microbes. As with drinking water, there is much double-counting in this problem area. It is included as a separate "special" problem area like drinking water because a true understanding of the overall risks to this resource is particularly important, and because such an understanding is difficult if the risks are split between many different problem areas.

6. Physical Degradation of Water and Wetland Habitats

Damages arising from alterations in the quantity and flow patterns of groundwater and surface water are included in this problem area. Such disturbances include channelization, dam construction and operation, surface and groundwater withdrawals, construction and flood control, irrigation distribution works, urban development, and the disposal and runoff of dredge and fill materials. Physical changes to water flow and aquatic habitats are included in this problem area, as is chemical contamination resulting from physical changes (e.g. dredging of contaminated sediments).

7. Storage Tanks

Storage Tanks includes routine or chronic releases of petroleum products or other chemicals from tanks that are above, on, or under ground, tanks owned by farmers, fuel oil tanks of homeowners, or other storage units (such as barrels). Stored products include motor fuels, heating oils, solvents and lubricants that have air emissions or can contaminate soil and groundwater with such toxics as benzene, toluene, and xylene. This category excludes hazardous waste tanks. Acute releases (explosions, tank collapse) are examined under Accidental Releases.

8. Hazardous Waste Sites with Active Disposal (RCRA)

This category generally includes the risks posed by active and inactive hazardous waste sites regulated under the Resource Conservation and Recovery Act (RCRA). These sites include RCRA open and closed landfills and surface impoundments, hazardous waste storage tanks, hazardous waste burned in boilers and furnaces, hazardous waste incinerators, and associated solid waste management units. Seepage and routine releases from these sources contaminate soil, surface water, groundwater, and pollute the air. Contamination resulting from waste

transportation and current illegal disposal are also included. Radiation from hazardous "mixed waste" from RCRA facilities is included in this problem area.

9. Hazardous Waste Sites with Past Disposal (Superfund)

This category includes hazardous waste sites not covered by RCRA, but by Superfund. Most are inactive and abandoned. Sites can be on the National Priorities List (NPL), deleted from the NPL, candidates for the NPL or simply be noted by the federal government or states as unmanaged locations containing hazardous waste. Sites may contaminate ground or surface water, pollute the air, or directly expose humans and wildlife. There are many pollutants, including TCE, toluene, heavy metals, and PCB's. Radiation from hazardous "mixed waste" in abandoned/Superfund sites is included in this problem area.

10. Industrial Solid Waste Sites

Industrial Solid Waste Sites includes open and closed industrial landfills, industrial sludge and refuse incinerators, and industrial surface impoundments. These sources can contaminate ground and surface water and pollute the air with particulates, toxics, BOD, microbes, PCDF's, PBB's, and nutrients. Contamination may occur through routine releases, soil migration or runoff. Most sites are regulated under Subtitle D. This category excludes active and inactive hazardous waste sites. Although the list of potential contaminants is similar to that of municipal solid waste sites, the concentrations, volumes, and mixes of pollutants found on typical industrial sites are frequently very different.

11. Municipal Solid Waste Sites (including open dumps)

Municipal Solid Waste Sites includes open and closed municipal landfills, municipal sludge and refuse incinerators, and municipal surface impoundments. These sources can contaminate ground and surface water and pollute the air with particulates, toxics, BOD, microbes, PCDF's, PBB's, and nutrients. Contamination may occur through routine releases, soil migration or runoff. Most sites are regulated under Subtitle D. This category excludes active and inactive hazardous waste sites.

12. Accidental Chemical Releases to the Environment

Contaminants may accidentally be released into the environment in a variety of ways during transport, storage, or production. An industrial unit may explode and emit toxics into the air, a railroad tank car may turn over and spill toxics into surface water or roads, or a ship may run aground and spill oil or other cargo into the environment. Damages to property, personnel, and wildlife may occur from intense, short term releases of toxic or flammable chemicals. Acids, PCB's, ammonia, pesticides, sodium hydroxide, and various petroleum products have been accidentally released.

13. Pesticides

This problem area addresses risks arising from the application, runoff, groundwater contamination, and residues of pesticides to humans and the environment. It included risks to people applying agricultural pesticides, including farm workers who mix, load, and apply them. Also included are risks to the public and non-target plants and wildlife as a result of short range drift, overspray, and misuse. Disposal of mixed pesticide wastes has resulted in the generations of highly toxic, largely unknown byproducts that have entered the air and caused serious health problems. Suburban spraying of property, often done with high pressure systems, can result in contamination of neighboring property, residents, pets, and livestock. Aside from direct exposure, additional pesticide risks stem from exposure through ingestion of residues on foods eaten by humans and wildlife. Bioaccumulation and food chain effects are also included in this category. Note that the accidental releases and indoor air pollution from pesticides are respectively included in the Accidental Releases and Indoor Air problem areas.

14. Food Contamination

This problem area includes the effects of all contaminants introduced through environmental channels into the food eaten by humans. It includes chemicals (including pesticides) bioconcentrated or bioaccumulated in organisms eaten as food by humans unless the chemical was intentionally applied to the food. The effects of pesticide residues on grain or fruit are thus excluded when the pesticides have been applied to these crops, but the effects of residues in fish or game that have eaten the grain or fruit are included. The effects of food additives (e.g., nitrites, growth hormones, dyes) are excluded. The effects of substances added during food storage, processing, or preparation are excluded.

15. Sulfur Oxides and Nitrogen Oxides (including Sulfates and Acid Deposition)

Sulfur Oxides and Nitrogen Oxides cause a wide variety of primary and secondary effects. Primary effects include health, visibility, and welfare impacts. A major secondary effect is acid deposition, which results from chemical transformation of oxides of sulfur and nitrogen, producing acid rain, snow, and fog, as well as dry deposition. Acid deposition alters the chemistry of affected aquatic and terrestrial ecosystems, damaging plant and animal life. Sources are a wide variety of industrial, commercial, and residential fuel and related combustion sources. This problem also includes visibility effects resulting from the long range transport of sulfates.

16. Ozone and Carbon Monoxide

Ozone and Carbon Monoxide are major air pollutants in many areas, arising from both mobile and stationary sources. Damage to forests, crops, and human health can be severe. Note that volatile organic compounds (VOC's) are critical precursors to ozone formation, but the direct effects of VOC's are included in the Air Toxics problem area. To the extent that VOC's result in ozone, those ozone effects are captured by this problem area.

17. Airborne Lead

Air emissions of lead result from many industrial and commercial processes. This problem area includes both direct exposure to lead and exposure to deposited lead from airborne sources. It does not include exposure to airborne lead from drinking water delivery systems or lead found in homes and buildings from leaded paint.

18. Particulate Matter

Both total suspended particulates (TSP) and fine particulates/PM10 are included in this problem area. Major sources include motor vehicles, residential fuel burning, industrial and commercial processes, and in some cases, strip or open pit mining.

19. Hazardous/Toxic Air Pollutants

This problem area covers outdoor exposure to airborne hazardous pollutants from routine or continuous emissions from point and nonpoint sources. Pollutants include asbestos, various toxic metals (e.g. chromium, beryllium), organic gases (benzene, chlorinated solvents), polycyclic aromatic hydrocarbons (PAH's, such as benzo(a)pyrene, primarily in particulate form), gasoline vapors, incomplete combustion products, airborne pathogens, cooling towers, and a variety of other volatile organic chemicals and toxics. The problem area covers exposure through both inhalation and air deposition of these pollutants to land areas. Runoff of pollutants deposited on land or direct deposition to surface waters is addressed in Nonpoint Sources. Major sources include large industrial facilities, motor vehicles, chemical plants, commercial solvent users, and combustion sources. This category excludes, to the extent possible, risks from pesticides, airborne lead, radioactive substances, chlorofluorocarbons, emissions from waste treatment, storage and disposal facilities, storage tanks, and indoor air toxicants.

20. Indoor Air Pollutants Other than Radon

This category applies to exposure to accumulated indoor air pollutants, except radon, primarily from sources inside buildings and homes. These sources include unvented space heaters and gas ranges, foam insulation, pesticides, tobacco smoke, wood preservatives, fireplaces, cleaning solvents, and paints. The pollutants include tobacco smoke, asbestos, carbon dioxide, carbon monoxide, nitrogen oxides, lead, pesticides, and numerous volatile organic chemicals such as benzene and formaldehyde. Occupational exposures are included, as is inhalation of contaminants volatilized from drinking water.

21. Indoor Radon

Radon is a radioactive gas produced by the decay of radium, which occurs naturally in almost all soil and rock. Risks occur when radon migrates into buildings through cracks or other openings in the foundation, water, or fuel pipes. The gas is trapped by dense building materials and can accumulate to very high levels. When inhaled, radon decay products can cause lung

cancer. This category includes radon volatilized from domestic water use, and also includes occupational exposures. The problem area does not include outdoor radon.

22. Physical Degradation of Terrestrial Habitats

Sources affecting terrestrial ecosystems/habitats include both chemical and non-chemical stress agents. Because chemical sources of degradation are addressed in other categories, this category includes physical modifications (such as mining and highway construction) and other sources of degradation (such as dumping of plastics and other litter) that affect terrestrial ecosystems/habitats. Effects on undisturbed lands/habitats that result from nearby degradation (habitat fragmentation, migration path blockage) are also included in this problem area. EPA often has no regulatory authority over sources of physical degradation, while in other cases it may be able to influence them through the NEPA/EIS process.

Appendix B: Background Papers on Problem Areas

Industrial, Municipal and Nonpoint Source Discharges	B-3
Drinking Water and Ground-Water Contamination	B-14
Physical Degradation of Aquatic and Terrestrial Habitats	B-22
Unintended Releases of Toxic Substances	B-26
Pesticides	B-34
Food Contamination	B-38
Criteria Air Pollutants	B-49
Hazardous/Toxic Air Pollutants	B-59
Indoor Air Pollutants Other than Radon	B-62
Radon	B-80
General References	B-83

Problems have been grouped for discussion in background papers as follows:

1. Industrial wastewater discharges to lakes and rivers
2. Municipal wastewater discharges to lakes and rivers
3. Nonpoint source discharges to lakes and rivers
4. Aggregated public and private drinking water supplies
5. Aggregated groundwater contamination
6. Physical degradation of aquatic habitats
22. Physical degradation of terrestrial habitats
7. Storage tanks
8. Hazardous waste sites with active disposal (RCRA)
9. Hazardous waste sites with past disposal (Superfund)
10. Industrial solid waste sites
11. Municipal solid waste sites (including open dumps)
12. Accidental chemical releases to the environment
13. Pesticides
14. Food contamination
15. Sulfur oxides and nitrogen oxides (including sulfates and acid deposition)
16. Ozone and carbon monoxide
17. Airborne lead
18. Particulate matter
19. Hazardous/toxic air pollutants
20. Indoor air pollutants other than radon
21. Indoor radon

Industrial, Municipal and Nonpoint Source Discharges

This paper provides information relating to three environmental problem areas:

1. Industrial wastewater discharges to lakes and rivers.
2. Municipal wastewater discharges to lakes and rivers.
3. Nonpoint source discharges to lakes and rivers

Available Data

We used several sources of data for this assessment:

- o The Wisconsin 305(b) report for 1990, which provides an assessment of surface water quality throughout the State. The assessment is based on a combination of monitoring results from fixed stations, special studies, and the field knowledge of DNR personnel. Unfortunately, these three sources tend to concentrate on large rivers, water bodies near populated areas, and water bodies with known problems. Rivers and lakes within the Wisconsin tribal reservations meet none of these criteria. Hence, the assessment data from the State is limited and not very specific regarding the condition of surface waters on the reservations.
- o The Wisconsin Nonpoint Source Assessment Report for 1988. This provides some additional data on surface water quality. It ranks types of nonpoint sources in terms of their impact on water quality statewide.
- o A study by EPA Region 5 identifying point sources that might potentially affect surface water quality on reservations. Point sources were defined as having a potential effect if they were within 30 miles upstream or within 10 miles adjacent in the case of lakes. In our view, this is a reasonably conservative way to identify potential impacts -- it typically requires a combination of a large discharger and a small stream to find significant impacts 30 miles downstream. 31 point source dischargers that could potentially affect reservation surface waters were identified in this study.
- o Anecdotal responses by the Wisconsin tribes about surface water problems and their sources provided in the 1988 CERT/GLIFWC study of tribal environmental needs. Problems were often cited in this study based upon speculation, and actual monitoring data to buttress the speculation is rarely available.
- o Miscellaneous publications regarding the health of fish populations and water quality in specific water bodies.

Findings From These Data Sources

The Wisconsin 305(b) report lists no water bodies on reservations among those "significantly impaired by point sources of toxic pollutants". The 305(b) report characterizes surface water quality as generally good in the northern and north-central regions of the state where the bulk of the reservations are located. Detailed water quality assessments are not available for the specific lakes and river reaches in reservations. Broader assessments by the State of the entire river basins within which the reservations are located show the following pattern:

o Water quality fully supports State of Wisconsin designated uses	14,709 miles (96 %)
o Water quality partially supports State of Wisconsin designated uses	498 miles (3 %)
o Water quality does not support State of Wisconsin designated uses	0 miles
o Water quality threatened	95 miles (1 %)

Water quality on the reservations appears to be substantially better than the average throughout the state -- statewide only 62% of the assessed stream miles fully support State of Wisconsin designated uses. Note, however, that these are State designated uses rather than Tribal ones. The uses the Tribes would like to make for waters (particularly with reference to their historical condition at the time the treaties were signed) are probably higher than are currently provided for by the State standards.

Data from the 305(b) report pertaining to the river basins within which the reservations are located clearly portray nonpoint sources (primarily agriculture) as contributing significantly more to water quality problems than point sources.

Information from the Region 5 study on point source dischargers potentially affecting the reservations is presented at the end of this paper. We supplemented the information from Region 5 with what we could learn quickly about each of the dischargers. Significant findings include:

- o 3 of the reservations have no point source dischargers that potentially affect them. Two reservations (Bad River with 13 and Red Cliff with 7) account for the bulk of the 31 potentially important dischargers.
- o Most of the 20 dischargers potentially affecting these two reservations are counted as doing so because they are within 10 miles of the reservations along Lake Superior. Lake Superior affords large dilution, and we doubt that any of the dischargers along the lake

actually affect these two reservations substantially.

- o Of the 31 potentially important dischargers, 7 are industrial, 23 are municipal and 1 is unknown.

- o Only 2 of the 31 dischargers are in significant noncompliance with their State permit limits. These are two small POTWs.

- o Of the 7 industrial dischargers, only 2 are listed in EPA's TRI data base as significant dischargers of toxic pollutants, one potentially affecting Bad River and one potentially affecting Lac Courte Oreilles. The other 5 industrial dischargers are unlikely to be significant sources of toxic effluents (one power plant, one sawmill, one food processor, and two fish hatcheries).

- o Of the 23 municipal dischargers, one serves a population of nearly 10,000 (Ashland, which discharges to Lake Superior). The remainder appear to serve populations of less than 3,000. Such small POTWs are unlikely to cause any significant water quality problems when they are in compliance with their State permit limits.

Actual or suspected surface water quality problems reported by the reservations for the CERT/GLIFWC survey and in subsequent comments are reported below. We have also noted the type of source (industrial, municipal or nonpoint) that is most responsible for each problem.

	I	M	NPS
Bad River:			
o Mercury in fish			x
o Concerns about Kakagon Slough, an important wetland and rice-producing area: problems with pleasure boats, sedimentation, maybe heavy metals and pesticides			x
o Failing septic systems			x
o Runoff from old toxic sludge storage site			x
Lac Courte Oreilles			
o Wild rice lost through dam and flooding			
o Sewage from resorts flows untreated into lakes		x	
o Possible runoff from open dumps			x

	I	M	NPS
o Off-reservation dam has changed water levels and interfered with fish spawning			
o Herbicides used on rights-of-way may run off			x
Lac du Flambeau			
o Mercury in fish			x
o Pulp mill outfall in lake	x		
Menominee			
o Sewage treatment improvements needed at Keshena		x	
Mole Lake			
o No problems cited			
Oneida			
o Agricultural pollutants -- pesticides, fertilizer, sediment			x
o Runoff from active and abandoned solid waste sites			x
Potawatomi			
o Sedimentation in lakes and streams			x
o Runoff from landfills and industrial sites			x
o Septic systems overloaded and poor condition			x
Red Cliff			
o Contaminants in Lake Superior fish: mercury, pesticides			x
St. Croix			
o Mercury in fish			x
o Rice harvest down, walleyes down, carp up		?	
o Water quality problems in Yellow River		?	

	I	M	NPS
o Septic system discharges			x
Stockbridge-Munsee			
o Plywood mill yard runoff	x		
o Tribal sewage treatment lagoons have potential impact		x	
o Septic system failures			x
Winnebago			
o Need sewage treatment plant. Septic systems inadequate		x	

General Conclusions About Surface Water Quality

Surface water quality on reservation lakes and rivers is generally very good, with the exception of the issue about contaminants in fish. Any other problems cited are localized and small. Most lakes are classified as mesotrophic, with relatively little nutrient enrichment. Few lakes are actually acidified, although most of the lakes are quite sensitive to acidification. Relatively few point sources potentially affect reservoir surface waters, and their actual impacts are probably minor.

Comparing the relative impacts of different sources of water quality problems, it seems clear that nonpoint sources (particularly air deposition and septic systems) are far more important than point sources. A relative comparison of the impact of industrial and municipal point sources is not so clear -- each causes minor impacts. On balance, it appears that municipal point sources cause slightly greater impacts than industrial point sources because of their greater prevalence and poorer compliance record.

Health Risks

Health risks from surface water contamination can arise in either of two primary ways: consumption of contaminated drinking water, or consumption of contaminated fish. No Wisconsin reservations obtain their drinking water from surface sources, so this pathway is not of concern. Consumption of contaminated fish, however, represents a substantial health risk to the average member of a Wisconsin tribe (see paper on food contamination). The contaminants primarily responsible for this health risk are PCBs and mercury. At present, these contaminants derive almost completely from nonpoint sources -- air deposition and natural minerals. Only a very few of the reservation lakes or rivers have point sources upstream of them. For the few water bodies potentially affected by point sources, PCBs and mercury may plausibly derive from current point source discharges or from past discharges that have contaminated sediments that are now still releasing these toxic substances. Nonpoint sources appear to cause substantial health

risks, while industrial and municipal point sources contribute minimal health risks.

It may be of interest here to summarize the recent research on the source of the mercury levels in fish. Mass balance studies of isolated lakes in northern Wisconsin indicated that nearly all of the mercury derives from wet (in rain and snow) and dry (in particles) deposition from the air, with a small amount from leaching from natural minerals. For most lakes, mercury contributions from point sources, runoff, or sediments are unlikely. Concentrations of mercury in precipitation are extremely low; perhaps 1/4 derives from industrial and municipal air emissions of mercury, 1/4 derives from fossil fuel burning, and 1/2 derives from natural air emissions (volcanoes and weathering of minerals). Current concentrations of mercury in precipitation appear 2 - 3 times as high as they were in pre-colonial times.

Mercury concentrations in lake waters in northern Wisconsin are often only 1/10 that in precipitation. However, fish concentrate the mercury that exists in their environment by factors of up to 1 million. Acid waters appear to play a critical role in facilitating conversion of inorganic mercury to organic forms that tend to concentrate in fish tissues (biomethylation of mercury into methylmercury -- a form easily assimilated in fish tissue). Typically, fish that are larger and older and higher up the food chain (large fish such as muskies, walleye and northerns that eat small fish) show the highest levels of mercury contamination. Typical concentration levels for mercury might be:

In precipitation	10 parts per trillion
In lake water	1 part per trillion
In large sport fish	1 part per million

The Wisconsin Department of Natural Resources (DNR) has been finding that about 1/3 of the lakes it tests in northern Wisconsin have game fish contaminated with mercury to a degree warranting issuing a fish consumption advisory for the lake.

PCBs show a somewhat similar pattern of sources and bioconcentration as does mercury. Air deposition is the primary source of the pollutant (for Lake Superior, 90% of PCB loadings come from air deposition), and larger, older predator fish show much higher concentrations. There are several differences between the nature of the problem with PCB and with mercury, however:

- o PCB concentrations in fish have been declining for the past decade or so, whereas mercury concentrations appear to be steady.
- o In several of the Great Lakes other than Lake Superior, point sources are a significant contributor of PCBs. This is particularly true in industrial harbor areas, where point sources and previously contaminated sediments continue to release PCBs.
- o No information suggests that acid deposition plays any role in causing increased concentration of PCBs in fish.

Ecological Risk

Perhaps surprisingly, the high concentrations of toxic substances in large fish in reservation areas do not seem to be symptomatic of substantial ecological damage. Although the concentrations are high enough to pose a health threat to human consumers of fish, the fish populations themselves in lakes and rivers near the reservations appear generally healthy. Extensive studies of fish populations in the ceded territories by the GLIFWC and WDNR have found:

- o Populations of walleye, muskie and northern pike are approximately stable over recent years despite increasing fishing pressure. Each of these fish is still found in most of its historical range. 56% of the lakes in which walleye can be found and 30% of the lakes in which muskie can be found have naturally self-sustaining populations of these fish. Most of the remainder of the lakes have populations that are maintained at least partly by stocking.
- o Deformities, lesions and tumors (typical signs of substantial stress to fish populations from toxic substances) do not appear to be common.

Nevertheless, there are some signs of ecological damage in aquatic ecosystems, largely from nonpoint sources:

- o Many acres of fish spawning beds have been silted over or actually filled in.
- o A few lakes have suffered acidification or accelerated eutrophication, with substantial resulting changes in the resident aquatic species.
- o Lake trout populations have declined sharply, partly due to the adverse effects of PCBs on development of the young fish larvae.

In general, populations of plant-eating fish (e.g., whitefish, perch) are healthier than those of predator fish, suggesting a broad impact from bioconcentration of toxic substances.

Additional damages to species other than fish have resulted to animals that consume large amounts of fish:

- o Young Forester's terns waste away through a condition induced by PCBs in their diet that is similar to starvation.
- o Cormorants have difficulty hatching because of edema (fluid retention in the head, neck, and abdomen preventing the chick from lifting its head to crack out of its shell), and some are born with deformities such as fused vertebrae and crossed bills. PCBs are suspected as the cause.

- o Bald eagles living inland have far greater reproductive success than those living near the Lake Michigan shoreline. Blood from young bald eagles living near the shore has up to nine times the concentration of PCBs as those hatched farther inland.
- o Mink and otter populations have declined very sharply (though potentially due to several factors in addition to toxic substances).

Like mercury, PCBs also bioconcentrate in animal tissues. PCB concentrations in tern eggs have reached 25 million times their concentration in water.

Social and Economic Damages

No studies are available quantifying the effects of various sources of water pollution on social and economic values in the areas of the reservations. We would estimate these effects as follows:

- o Diminution of cultural and religious values. There could be substantial losses here. The knowledge that a large portion of the Tribes' traditional fishing grounds is populated with fish not fit for consumption and that many additional areas may also be contaminated substantially reduces these values.
- o Damage to subsistence activities. Tribal catch levels and the amount of effort expended per unit of catch both seem to be holding reasonably constant over the past 5 years. Over a longer time period, effort per unit catch has clearly increased. However, this is probably more a result of greater fishing pressure than of pollution.
- o Damage to commercial fishing. The Red Cliff commercial fishing operation has become more difficult as a result of declining populations of some Lake Superior species. The population declines result jointly from fishing competition and the lamprey eel as well as pollution.
- o Surface water pollution might also be expected to cause some damages to tourism, health care costs, reduced recreational opportunities, and aesthetic concerns.

List of Point Source Dischargers Potentially Affecting Reservation Waters

<u>Name of Discharger</u>	<u>Municipal or Industrial</u>	<u>Comments</u>
Bad River		
Anderson S.D.	M	Unknown small # served
Ashland	M	9615 served
Bad River Tribe	M	About 1000 served
Hurley	M	2418 served
James River Co., Ashland	I	Pulp mill, in TRI
Knight	M	Unknown small # served
Knowles Mgt. Co.	?	?
Mellen	M	1168 served
Montreal	M	877 served
Northern States Power, Bayfield	I	Power plant, not in TRI
Pence	M	< 1000 served
Saxon	M	< 1000 served
WI-DNR Copper Falls St. Park	M	Small
Forest Co. Potawatomi		
Wabeno S.D.	M	800 served
Lac Courte Oreilles		
Louisiana Pacific Co., Hayward	I	Paper mill, in TRI
Lac du Flambeau		
Lac du Flambeau Tribe	M	About 1500 served
Menominee		
Keshena Well #1	M	Iron from water tmt.
Menominee Tribal Enterprise	I	Sawmill, probably with little toxics
WI-DNR Langlade Rearing	I	Hatchery, probably with little toxics

Oneida

Hill Ctr -- Oneida Tribe	M	Small
Oneida Res. Site I	M	Total served about 1000 for
Oneida Res. Site II	M	the two sites. Oneida Site I in noncompliance for BOD, TSS, bacteria
Provimi Inc.	I	Food processing, not in TRI. Probably with little toxics

Red Cliff

Bayfield	M	874 served
Bell San. District	M	Small
Madelaine S.D.	M	Small
Ondossagon Public School	M	Small
Pikes Bay S.D.	M	Small. Noncompliance for TSS
Washburn	M	1957 served
WI-DNR Bayfield Hatchery	I	Hatchery, probably with little toxics

Stockbridge-Munsee

Stockbridge-Munsee WWTP	M	< 1000 served
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Drinking Water and Ground-Water Contamination

This paper provides information relating to problem areas # 4 and # 5, "Aggregated Public and Private Drinking Water Supplies" and "Aggregated Ground-Water Contamination."

Available Data

We used several sources of data for this assessment:

- o Wisconsin's 1988 Nonpoint Source Assessment Report, which contains an extensive review of ground-water quality and contamination incidents, including maps of the locations where nitrate, pesticide and VOC contamination has been detected.
- o Qualitative reports about drinking water quality for each of the Wisconsin reservations. These are relevant to both the drinking water and ground-water issues because all of the tribes rely on untreated or minimally treated ground water as their source of drinking water. The quality of drinking water as it arrives at the consumer's tap is virtually identical to the quality of the ground-water source.
- o Data from Region 5 and the CERT/GLIFWC study on violations of drinking water standards by community water systems for the reservations. Unfortunately, the monitoring data available for community water systems on the reservations cover microbiological contaminants only.
- o A variety of materials describing the amount of activities that might potentially contaminate ground water that occurs on reservations, including: USTs, household waste dumps, industrial waste sites, septic systems, abandoned wells, and spills.
- o A DRASTIC map for the state, indicating the vulnerability of ground water in each reservation to contamination from surface sources.
- o Specific data on nitrates, radionuclides and other contaminants in ground water for some reservation areas.

Evaluation of Drinking Water and Ground-Water Quality

All Wisconsin tribes draw their drinking water from ground water sources. Roughly half the population is served by community water systems and half relies on private wells. Most of the private wells and many of the community wells are shallow at roughly 50 feet in depth. Some of the community wells are drilled as deep as several hundred feet. Many of the community water systems provide no treatment. A few are chlorinated (though studies reveal that a chlorine residual is often not maintained throughout the distribution system) and several are

fluoridated also. Several systems use iron filters to remove undesirably high concentrations of iron. Water from private wells is rarely treated.

Relative to water systems elsewhere in the country, those serving Wisconsin tribe members provide very little treatment. As a result, the quality of ground water underlying the reservations and the quality of the drinking water consumed by reservation residents are virtually identical.

Natural ground water quality in the area of the reservations is generally good for drinking and other purposes, with the following exceptions:

- o High levels of radioactive contaminants are widespread in central and northern Wisconsin. Perhaps half or more of the reservation community water systems would violate the currently contemplated EPA MCLs for radioactive constituents. Radon volatilized from drinking water may contribute a small fraction (perhaps 5%) of the radon in reservation homes.
- o Many systems are plagued with high natural iron levels. Although iron causes no health risk, it gives the water an unpleasant taste and smell and can stain laundry and other materials. Complaints have been noted about drinking water taste and smell problems on at least five of the Wisconsin reservations.
- o In extremely rare situations, cadmium and fluoride occur naturally in sufficient concentrations to exceed health based standards.

Anthropogenic contamination shows the following pattern:

- o Nitrate levels averaged 13.5 mg/l (relative to the MCL of 10 mg/l) in sampled wells on the Stockbridge-Munsee reservation. Judging from the pattern of agriculture in the state and the locations at which nitrate exceedances have been found, nitrate concentrations are probably similarly high for the Oneida reservation and some of the Winnebago and St. Croix communities. Exceedances of the nitrate standard are rare on the other reservations. An overlay map is available showing the locations of monitored nitrate exceedances relative to the locations of Wisconsin reservations.
- o Pesticides have virtually never been detected in wells on reservations at levels exceeding standards (see overlay). They are rarely detected at any level in wells on reservations (see overlay).
- o VOCs have virtually never been detected at levels exceeding standards in wells on reservations, with the exception of several instances in the Winnebago and St. Croix areas (see overlay). VOCs are generally a good marker for anthropogenic chemical contamination from USTs, waste sites, or spills. This result is expected, as USTs, hazardous wastes, industrial dumps and chemical spills are all relatively rare on

reservation lands.

- o Microbiological contaminants are monitored on a regular basis by the community water systems on reservations. Reported violations of the MCLs are very rare.

- o However, there are extensive reports of poorly functioning septic systems on reservations. Septic systems are likely located near private wells, and perhaps public wells are nearby also. Bacteriological contaminants from imperfect septic systems may easily contaminate ground water and drinking water supplies, especially when: a) Ground-water wells are typically shallow, and b) Numerous old improperly abandoned wells provide conduits for migration of contaminated water from the surface to aquifers.

- o The Wisconsin reservations are in areas where ground water is generally quite vulnerable to contamination from surface activities. It is the extremely low rate of such surface activities on reservations that is responsible for the usually good quality of ground water on the reservations.

- o We have no data on lead levels in drinking water in reservation homes. We would guess that such levels are low, as much of the reservation housing is relatively new and use of lead pipe and solder are rare in newer housing and water supplies on the reservations are not particularly corrosive. However, harmful effects are being found from lead at ever-diminishing levels, and lead in reservation drinking water is an issue worthy of further research.

Health Risks

We judge the health risks from the different classes of contaminants in reservation drinking water and ground water to be as follows:

- o Pesticides: minimal.

- o VOCs: minimal

- o Metals other than lead: minimal

- o Radionuclides: substantial. It is common nationally for about 5% of indoor radon in homes to derive from drinking water/ground water. If this is the case on the reservations, the average member of a Wisconsin tribe faces an excess lifetime cancer risk of 1×10^{-4} from radon in drinking water/ground water.

- o Microbiologicals: perhaps moderate. Although the community water systems on the reservations rarely report a violation of the bacteriological MCLs, we are nevertheless concerned that the minimal treatment given to reservation water supplies combined with the widespread reports of septic system failures could lead to frequent bacteriological

contamination of reservation water supplies. We expect that a substantial portion of the incidence of gastrointestinal problems among Wisconsin Indians may be due to bacteriological contamination of water supplies. Limited data are available on the frequency of gastrointestinal problems. The Menominee Tribal Clinic reports about 100 cases annually of gastrointestinal problems prompting clinic visits. Extrapolating to all the Wisconsin tribes, about 600 total cases might be expected per year.

o Nitrates: minimal. Although water supplies exceeding the nitrate MCL are probably common for four tribes, the specific health effect that the nitrate MCL protects against - methemoglobinemia -- occurs extremely rarely. Less than 5 cases are reported annually for the entire U.S.

o Lead: unknown. Risks from lead in drinking water at the tap may be low, but we have no actual data on this issue. Lead does not occur in ground water on the reservations at levels of concern. Sampling of tap water and blood for lead levels would be worth while.

Ecological Risk

Drinking water contamination poses no ecological risks. Contaminated ground water may eventually discharge to surface water and cause ecological risks, but this effect is typically defined to be covered in the "Nonpoint Sources" problem area.

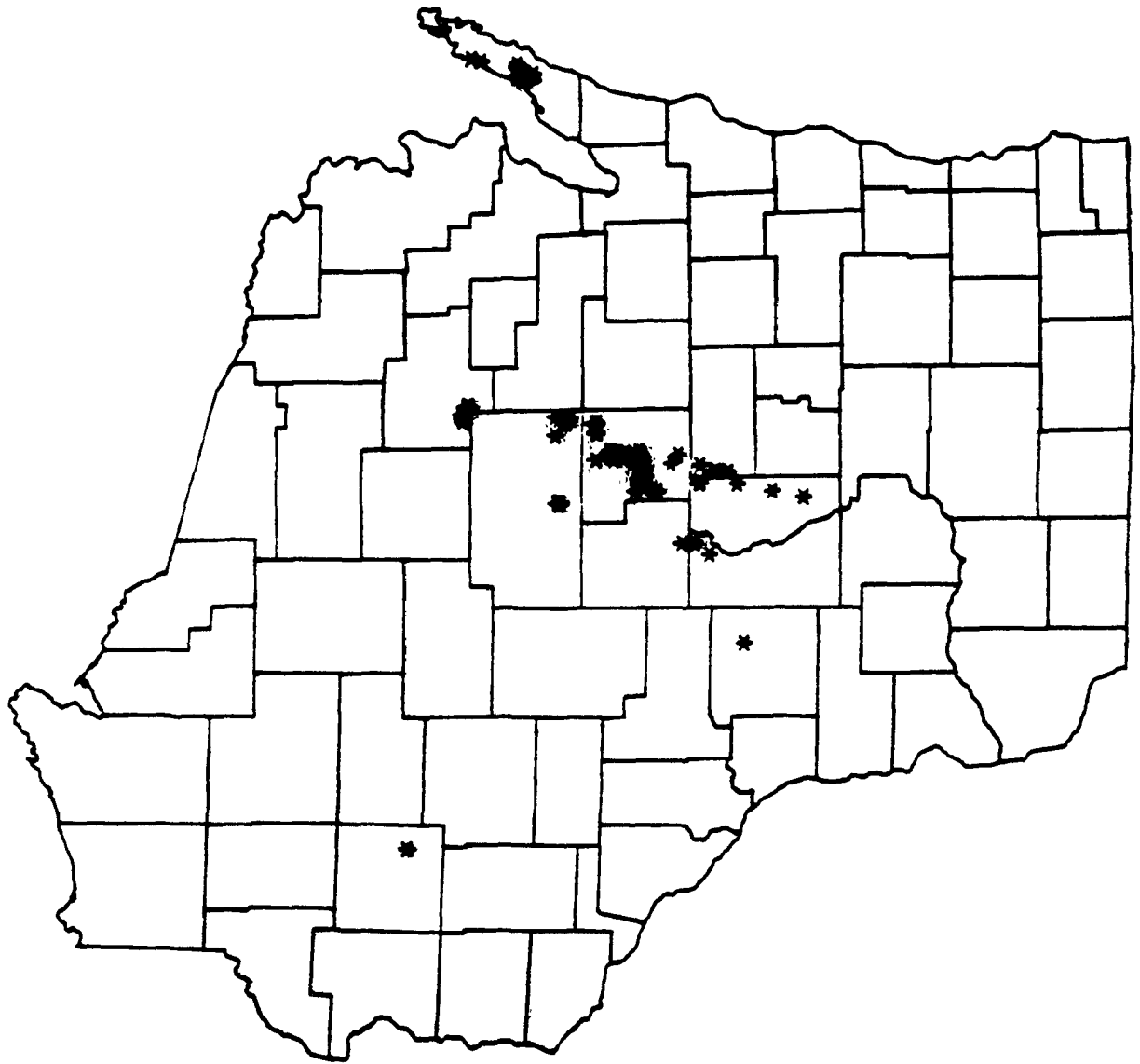
Social and Economic Damages

High levels of iron in some private wells and community systems for several reservations cause taste and odor problems. Some individuals may purchase bottled water at high cost to avoid these problems. Several community wells are treated for high iron levels, at a cost of perhaps a few thousand dollars per year. Several wells have been closed because of problems with iron.

There is no indication that any other water supply expenses (e.g., for treatment or for new wells) have been incurred by Wisconsin tribes because of contamination of ground water or drinking water.

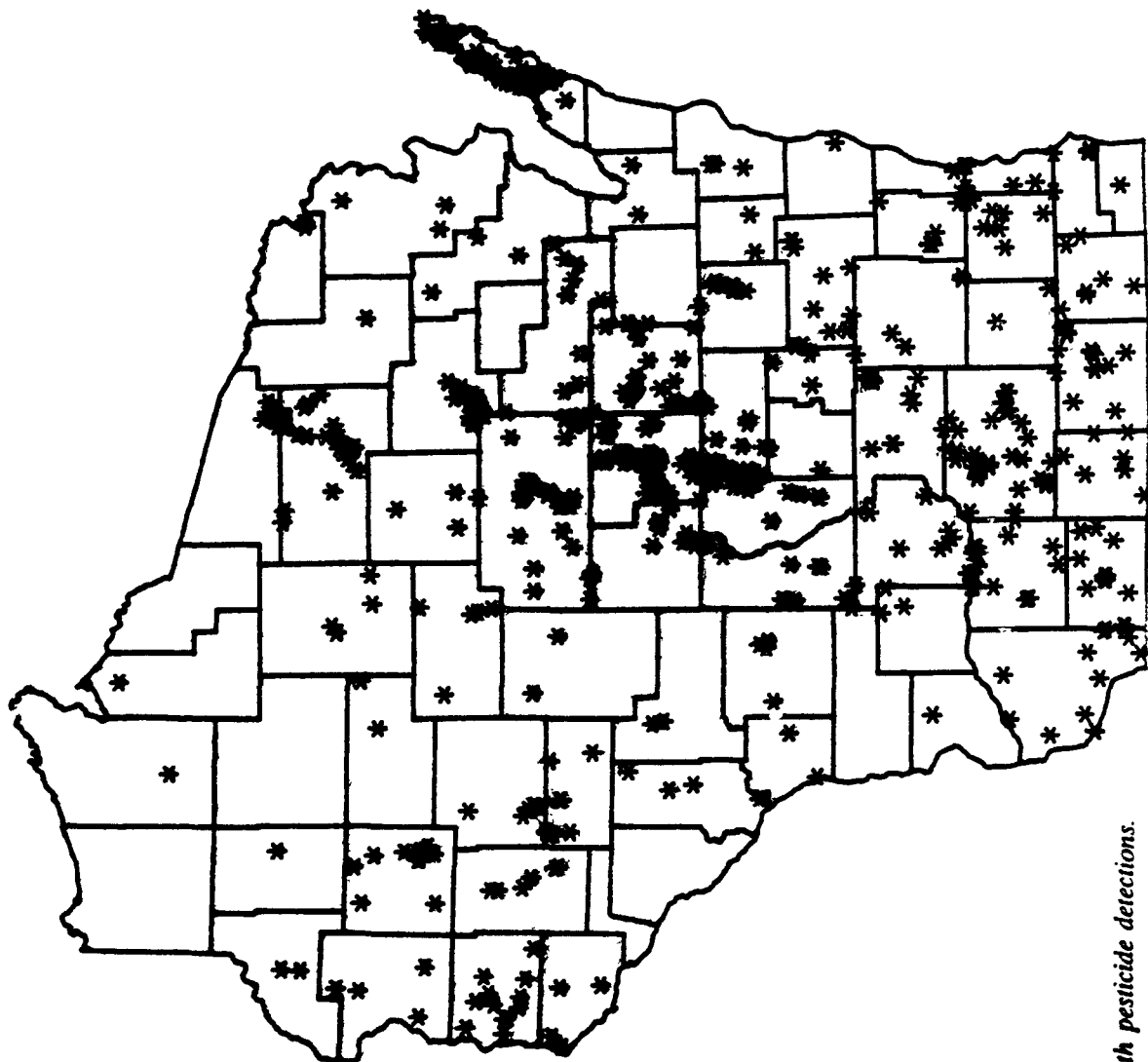
Adverse health effects from radon and microbiological contaminants will result in costs for medical treatment and lost productivity by those who become ill.

Pesticide exceedances in Wisconsin



Pesticide Detects in Wisconsin

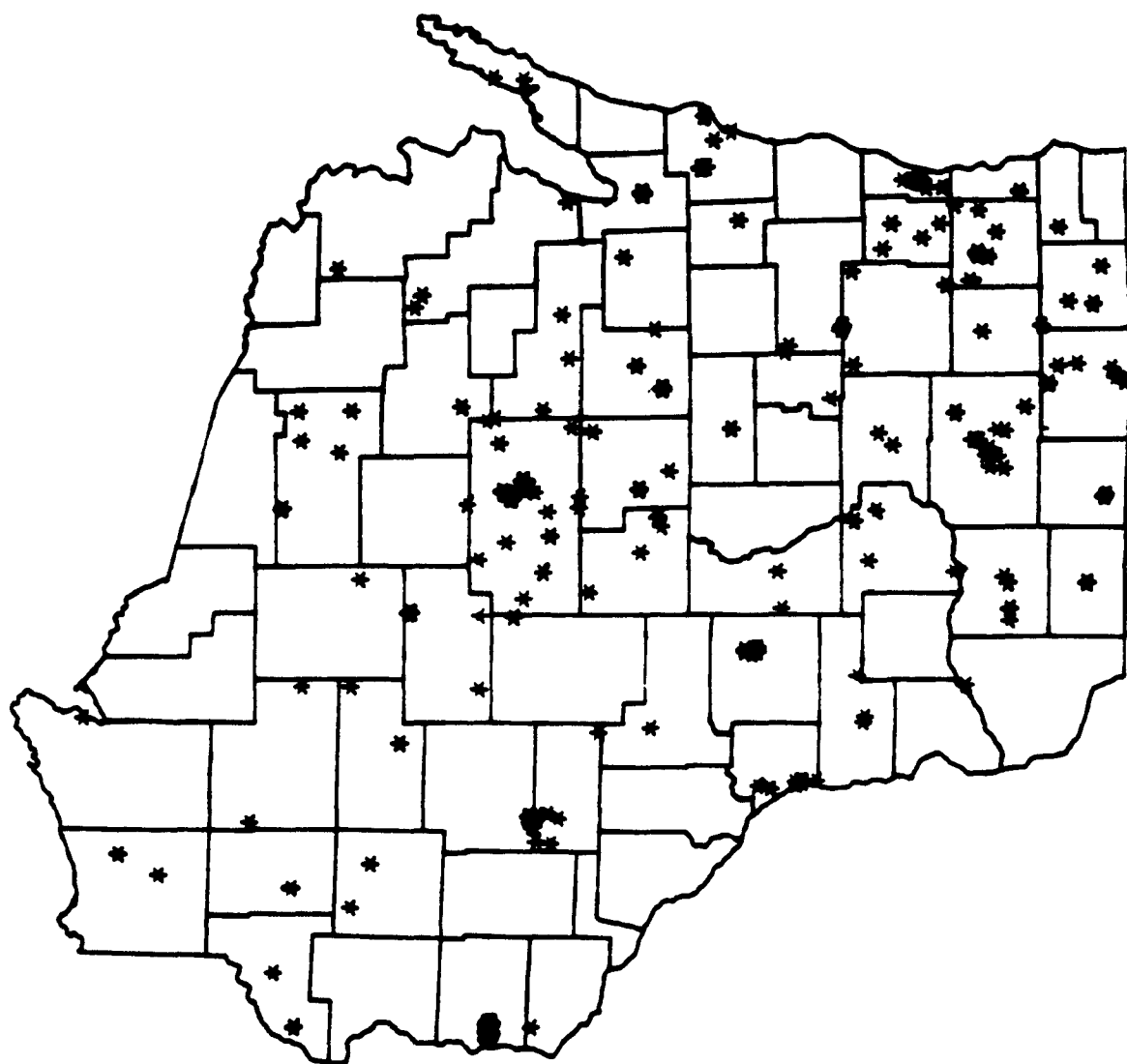
From January 1, 1980 to January 1, 1990



Wells with pesticide detections.

Volatile Organic Chemical exceedances in Wisconsin

Detected to date --- 1987



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Physical Degradation of Aquatic and Terrestrial Habitats

This paper provides information relating to two environmental problem areas:

6. Physical degradation of water and wetland habitats, and
22. Physical degradation of terrestrial ecosystems/habitats.

Aquatic Habitat Alteration

A variety of physical activities -- in addition to pollution -- have altered the nature of the water and wetland habitats on the reservations. Although the quality of the aquatic habitats on the reservations is generally quite good in comparison with off-reservation areas, the reservation aquatic ecosystems are nevertheless substantially altered relative to the way they existed many decades ago. The pace of alteration appears to have slowed in recent years, with habitat-disturbing activities occurring less frequently now than in the past.

The following are the activities thought to lead to significant alteration of the reservations' aquatic ecosystems:

Residential and recreational development. For several decades, some of the Tribes were actively seeking revenue by leasing or selling their most desirable waterfront lands to outsiders. This has resulted in a substantial amount of low density waterfront development, including resorts, cottages, cabins and docks. The numerous small developments involve fill and alteration of wetlands and shoreline spawning areas, reduction of shoreline fish cover, modification of water flow patterns, and increased siltation. Maps drawn from aerial photographs are available from the Wisconsin Geological Survey that show the extent of this development. We have reviewed the maps for the lakes and rivers within the reservations, and find that shoreline mileage is distributed among different uses in the following rough proportions:

- o Urban high intensity development. 0 - 5 % of shoreline in all reservations.
- o Low to medium density non-agricultural development. 5 - 20 % of shoreline for most reservations.
- o Agricultural development. 2 - 20 % of shoreline for all reservations other than Oneida, for which 80 % of the shoreline is agricultural.
- o Undeveloped. Most commonly about 70 - 80 % of a reservation's shoreline is undeveloped.

The maps are available for review by the work group, but cannot be reproduced here because of

their very fine level of detail.

Water management projects. Several water bodies in reservations have been sharply affected (and in some cases have been created) by off-reservation hydropower dams, flood control projects and channelization. The Lac Court Oreilles Reservation, for example, lost much of its historical wild rice acreage because of an off-site dam and flooding. Over 25 hydropower projects affecting the reservations and ceded territories, some involving many separate dams, are scheduled for relicensing by the FERC during the 1990's.

Introduced species. The sea lamprey was introduced to the Great Lakes by the maritime industry many decades ago. Lampreys are responsible for much of the precipitous decline in the lake trout population, and, despite extensive control efforts, still consume valuable fish at a rate exceeding that for commercial, sport, and subsistence fishing combined. A more recent concern in northern Wisconsin is purple loosestrife, an exotic perennial plant introduced to the southern U.S. over a century ago. Once established in wetland habitat, loosestrife tends to dominate the plant community and out-competes native species. Efforts to control the spread of loosestrife in reservation wetlands are showing mixed results.

Fishing pressure. Fishing may be considered to be another important form of aquatic habitat alteration. Fishing pressure in northern Wisconsin has clearly increased by historical standards, although it seems relatively constant over the past decade or so. Annual statewide sales of fishing licenses reached about 1 million in 1948, increasing gradually to 1.5 million in 1982 and then declined to about 1.4 million in 1989. Recreational, commercial and subsistence fishing are controlled by the Wisconsin DNR and the GLIFWC so as not to deplete sustainable fish populations.

Agriculture. For several reservations, notably Oneida, with Stockbridge-Munsee and St. Croix to a much lesser degree, agricultural development has substantially affected aquatic habitats. Draining of wetlands and siltation are major impacts that typically accompany agriculture.

The impact of these sources of habitat alteration on aquatic ecosystems in the reservations is mixed. Some water bodies have been completely changed by major water projects. Other water bodies are virtually unaffected.

Populations of key inland fish (walleyes, muskie and northern pike) are approximately stable over recent years across the studied lakes in the ceded territory. Each of these fish is still found in some lakes throughout nearly all of its historical range, but many individual lakes have lost their populations of these fish. 56 % of the lakes in which walleye can be found and 30 % of the lakes in which muskie can be found have naturally self-sustaining populations of these fish. Most of the remainder of the lakes have populations that are maintained at least partly by stocking.

Habitat alteration appears to have had a major adverse impact on wild rice. Wild rice is

quite sensitive to alterations in water levels, shoreline development and introduced species, and can even be damaged by boat wakes. Wild rice acreage and density have declined sharply within the memory of many Wisconsin Native Americans. Data collected more recently show a decline of about 25 % during the five years from 1985 through 1989.

Terrestrial Habitat Alteration

For most reservations, the percentage of the overall land area that has been developed appears to be less than the percentage of the shoreline that has been developed. Despite pockets of residential and commercial development, most reservations retain their historical natural, forested and wetland character. We reviewed a large map of Wisconsin showing gross land uses. Only the Oneida reservation showed any significant land use other than natural forest and brush land, wetland and surface water. Population densities across the reservations average only about half of that throughout Wisconsin as a whole.

Activities occurring on the reservations that alter terrestrial ecosystems include:

- o Agriculture. Most reservations have little agricultural development. Oneida, however, has been largely transformed by agriculture, and agricultural development is extensive also in the St. Croix areas.
- o Residential and commercial development. All reservations have small but growing settled areas, with cabins, recreational camps and roads, power lines and other associated facilities adding to the impacts from development.
- o Timber harvesting. Most of the reservations have active timbering programs, including in some instances clearcutting. These operations are carefully managed for sustained yield. Although substantial ecological changes occur on and immediately around a logged tract, the portion of the reservations' total area that is undergoing logging at any one time is quite small. For example, timber harvesting on the Menominee Reservation has remained at a nearly constant annual level since 1915. About 1.5% of the volume of sawtimber and pulpwood is cut each year. This amount is set at less than natural growth and replanting, so that there is a slow net increase in timber value over time, at somewhere between zero and one percent per year.

The impact of these activities on the ecological character of most reservations is in some ways not discernable. The composition of the forests remains largely unchanged. Populations of those species whose abundance has been surveyed (bear, deer, grouse, rabbits) are constant or increasing. Some ecological changes are apparent, however. Populations of eagles and furbearers have declined substantially in recent memory. While some of this decline may be due to habitat alteration, much of it is probably due to bioconcentration of pesticides and mercury in the food of these species.

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Wisconsin Department of Natural Resources. Map: Generalized Land Cover Interpreted from ERTS -1 Satellite Imagery.

Wisconsin Department of Natural Resources. Maps: Shoreland Use in Wisconsin.

Unintended Releases of Toxic Substances

This paper provides background information on 4 problem areas involving unintentional releases of toxic substances (whether products or wastes) to the environment:

7. Storage tanks
8. Hazardous waste sites, both managed (RCRA) and unmanaged (Superfund)
9. Solid waste sites, both industrial and municipal (including open dumps)
10. Accidental chemical releases to the environment

Available Data

Data of three sorts was acquired relating to these four problems:

- o Measures of the extent to which storage tanks, hazardous waste sites, solid waste sites and accidental releases occur on the Wisconsin reservations.
- o Monitoring data around specific sites at which some of these activities have occurred on the Wisconsin reservations.
- o Statewide data on the locations at which elevated concentrations of VOCs (the most common indicator of pollutant releases from these activities) have been detected in ground water.

These data have been interpreted below to provide a very rough impression of the degree of risk from each of these problems.

Overview

These four activities typically concentrate in areas of high population density and high industrial activity. Neither of these qualities typify the Wisconsin reservations, and the numbers of storage tanks, hazardous wastes sites, solid waste sites and accidental releases are low. Coupling this low threat with the very low density of residences on reservations, there are generally few people living near these activities on the reservations, and potentially exposed populations are very low.

If a release of toxic contaminants occurs on a reservation, however, it is generally likely to affect ground water. According to Wisconsin's DRASTIC map, most of the reservations are characterized by a rather high vulnerability of ground water to any contamination occurring on the surface.

The Wisconsin DNR has compiled data throughout the state on occurrence of VOCs in ground water, and has mapped the areas where elevated concentrations of VOCs have been detected. Virtually none of the detections of elevated VOC concentrations have been on reservations (see overlay at end of drinking water and groundwater contamination background paper).

There are no documented incidents we are aware of in which releases from one of these four source types has affected a drinking water supply on a reservation.

Storage Tanks

An inventory of storage tanks on Wisconsin reservations totals 205 tanks across the 11 reservations (see attachment). It is not clear whether the inventory counts only active tanks or abandoned ones also. We assume that this is the number of active tanks. This represents a density of about 1 tank per 3,000 acres of reservation land. This is much lower than the density of tanks throughout all of Region 5 of 1 tank per about 600 acres of land.

At least one UST on a reservation has been found to be leaking (a gasoline tank at a convenience store on the Oneida reservation). The release has been cleaned up at a cost of several tens of thousands of dollars, and no apparent health or ecological damage has occurred.

Region 5 estimates that between 10 and 30 percent of all USTs are probably leaking. We assume that this is likely to be the case for the reservations also. However, we believe that health and ecological risks from USTs on reservations are likely to be very low for two reasons:

- o The very low density of USTs on reservations.
- o The likelihood of quickly noticing a release whenever it reaches the point of being able to cause risks. Gasoline is quickly apparent when it either reaches a water supply (distinctive taste and odor) or reaches surface water (distinctive sheen or slick). Social and economic losses in the form of cleanup costs and the cost of lost product may be modest for USTs.

Hazardous Waste Sites

There appears to be very little hazardous waste on the Wisconsin reservations, probably as a result of the minimal history of industrial activity on the reservations. There are two known abandoned hazardous waste sites potentially affecting the reservations:

- o The Fort Howard Sludge Lagoon site on and adjoining the Oneida reservation. A Remedial Investigation under Superfund is due to be completed in 1993. Data has shown the presence of contaminants within the waste, ground water and air. Health risks will be determined in the Remedial Investigation Report.

- o An abandoned industrial sludge lagoon on the Bad River Reservation. It is being investigated.

Several other sites have been evaluated for Superfund listing, but have been found not to pose a sufficient threat.

Very little hazardous waste is now generated on the reservations. None is known to be disposed or stored for long periods on the reservations. Several small industrial plants (e.g., Simpson Electric on the Lac du Flambeau reservation) are small quantity generators who ship their hazardous wastes off the reservations for disposal. Medical waste is generated at several clinics and shipped off-site.

Hazardous waste, at both managed and unmanaged sites, appear to pose minimal risks to reservation residents and ecosystems.

Solid Waste Sites

The Wisconsin tribes have a history of indiscriminate open dumping of household wastes. Dump sites are scattered throughout the reservations. Most are now formally inactive, but have not yet been cleaned up. At present two reservations (Menominee, Lac Courte Oreilles) continue their open dumping, while the other 9 reservations have the bulk of their household refuse hauled off the reservations to county or other landfills. There do not appear now to be any environmentally satisfactory land disposal or incineration facilities on any of the reservations. Pieces of information about solid waste disposal on the reservations that we find relevant to a judgment about risk include:

- o Many of the existing open dumps are in very poor condition, with widely scattered trash, large rodent populations and inadequate or no provisions for periodic covering of the dumped material.
- o Many of the dump sites are (perhaps intentionally?) far from any residence or water well.
- o Three reservations cited open dumps as a possible source of surface water quality problems in the CERT study.
- o The material that has been placed in the dumps is almost exclusively household trash, of very low toxicity. There are almost no industrial solid waste dumps.
- o Ground-water monitoring has evidently been conducted around one of the Menominee dump sites. It apparently shows some ground-water contamination, but we were not able to obtain this data.

It is unclear what this information adds up to in terms of an assessment of the risks from

solid waste sites. We estimate that the health risks from these sites is very low, and that ecological risks and social and economic damages may be slightly higher.

There appear to be no industrial solid waste sites on the reservations.

Accidental Releases

There are no industrial or other facilities on Wisconsin reservations that have the potential of releasing significant amounts of toxic substances. The TRI data base shows very few such facilities in the immediate vicinity of the reservations.

We obtained data for the Menominee reservation listing hazardous material spills over the past ten years (attached). Most of the incidents involved spills of petroleum products. None appeared to cause any significant health or ecological damages. Some cleanup costs were incurred. Assuming that the other reservations have a history of release incidents similar to that for Menominee, risks from accidental releases are minimal.

Wisconsin reservations

<u>site</u>	<u>Number of tanks confirmed per Bob Fey data</u>
Bad River	6
Forest County Executive Cncl	0
Lac Courte Oreilles	52
Lac Du Flambeau	59
Menominee	36
Oneida	41
Red Cliff	2
Stockbridge-Munsee	6
Mole Lake	1
St. Croix	2
Winnebago	<u>0</u>
Total	205

HAZARDOUS MATERIALS SPILLS

1981 THROUGH PRESENT

MENOMINEE INDIAN RESERVATION

- 08/12/81 Gasoline tanker overturned on Highway 47 just west of Zoar. Lost approximately 5000 gallons of gasoline. Contaminated soil removed, monitoring wells installed, site determined to be cleaned.
- 09/02/83 Fuel oil tanker overturned on Highway 47 just east of the Langlade line. Lost 5000 - 7000 gallons of #2 fuel oil. Contaminated soil removed and disposed of. Site determined to be clean.
- 11/12/83 200 gallon fuel oil tank knocked over and spilled material on ground. Material absorbed and disposed of by WisDNR personnel.
- 11/06/84 Foundry sand dumped illegally in the Keshena dump. Material determined to be non-hazardous and allowed to remain on site. However, such material must be disposed in a licensed, properly constructed sanitary landfill.
- 12/13/84 Small fuel oil spill on Highway 55 associated with a truck crash. Lost 5 - 10 gallons of fuel. As per DNR recommendation, because of remote location, and small amount of spill, no cleanup required.
- 03/31/86 Found a 55 gallon drum of boiler treatment at the Keshena dump. Shipping labels etc on drum. Contacted owner and drum was removed intact.
- 03/10/87 Gasoline tanker ran off Highway 47 just west of Zoar. Ruptured and burned. Contaminated soil removed and disposed of. Monitoring wells installed. Continual installation of additional monitoring wells and sampling taking place. Site has not yet been determined clean.
- 09/15/87 Two 55 gallon drums of windshield deicer found at Keshena dump. Drums removed intact and disposed of properly.
- 12/15/88 Fuel oil tank leak at a private residence on fee land. May have occurred over 3 year period. Because of private land, homeowner is responsible for clean-up. As of this time no work has been done. Advised homeowner to request assistance from Tribe.
- 06/21/89 Three 55 gallon drums found in area of Jackson Creek. Investigation revealed all barrels to have been empty and rusted through before they were dumped. No contamination.

- 12/22/89 Small fuel oil spill in Neopit from a broken hose on a delivery truck. Confined to the surface on asphalt road. Product picked up with absorbent material. No ground contamination.
- 08/26/90 Small diesel oil spill occurred when a truck leaked fuel along a 11.3 mile stretch of Highway 47. Determination made only effect is in the area where the truck finally stopped. Contaminated material excavated and disposed in Shawano Landfill.
- 02/10/91 Truck crash on Highway 47 at Kakkak Hill lost unknown amount of diesel fuel from saddle tanks. Estimate from owner of 50-60 gallons. Contaminated soil removed to Shawano Landfill. Shallow ground water appears contaminated. Further work will be done.
- 07/25/91 MTE Mill in Neopit lost 2000 gallons of wood treatment into the ground. Working on mitigation.
- 07/25/91 Truck crash on Highway 55 caused a spill of fuel oil from the saddle tanks. Unknown amount of fuel lost, estimate somewhere between 80 and 200 gallons. Contaminated soil removed to Shawano Landfill. Samples collected of soil. Waiting for final interpretations of results.

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Sources

Correspondence between the U.S. Environmental Protection Agency, Region 5, and the Oneida Tribe regarding leaking underground storage tanks (USTs).

U.S. Department of Health and Human Services, Indian Health Service. Reports on Solid Waste Disposal System Surveys for each Reservation. 1991.

Jackson, D., Indian Health Service. FY '91 Solid Waste Status Report. 1992.

Secretary of Health and Human Services. Annual Report: Sanitation Facilities Deficiencies for Indian Homes and Communities. March, 1990; February, 1991.

U.S. Environmental Protection Agency, Region 5. Memorandum from David A. Ullrich, Wisconsin Tribal Comparative Risk Report (provides information regarding wastes on reservations). 30 July, 1991.

U.S. Environmental Protection Agency, Office of Waste Programs Enforcement. C.E.I. Inspections on Indian Lands Final Report. 25 September, 1989.

Pesticides

Some persistent, older, now-banned pesticides contribute moderately to the significant risks involved in Indian consumption of harvested fish and game. Currently used pesticides appear unlikely to cause significant health or ecological risks on the reservations. Locations where pesticides have been detected in ground water throughout the state only rarely include sites on reservations (see map overlays in Drinking Water and Groundwater Contamination background paper in addition to those following this paper). Most of the counties in which reservations are located are among the counties across the state where pesticides are least frequently used. However, farming activity is common in the vicinity of the Oneida, Stockbridge-Munsee, Winnebago and St. Croix reservations, and the intensity of pesticide usage in these areas is more like the typical level in the state. The attached chart shows pesticide usage in reservation counties in comparison to other counties in the state within the Great Lakes Basin.

Sources

Gianessi, Leonard P. "Use of Selected Pesticides on Agricultural Crop Production in the Great Lakes Region." March, 1988.

Wisconsin Department of Natural Resources. Nonpoint Source Assessment Report. August, 1988.

PESTICIDE USE IN WISCONSIN'S GREAT LAKES BASIN

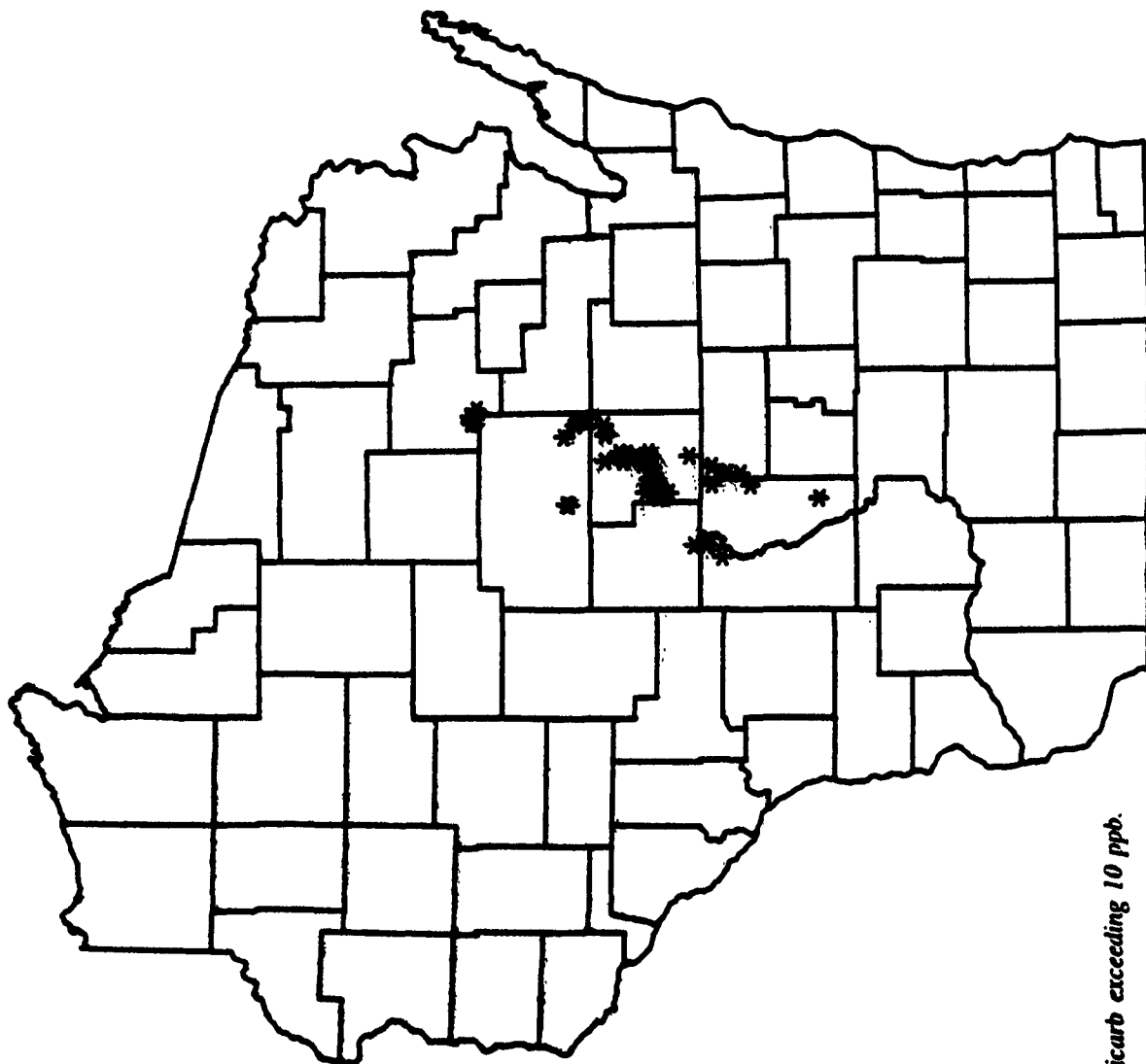
County	Total Pesticide Use (lbs. a.i.)	% Total Usage
* Ashland	6,452	0.16%
* Bayfield	7,381	0.18%
* Brown	205,180	5.00%
Calumet	149,841	3.65%
Door	80,613	1.96%
Douglas	3,823	0.09%
Florence	6,430	0.16%
Fond du Lac	446,316	10.87%
* Forest	1,264	0.03%
Green Lake	205,989	5.02%
* Iron	1,728	0.04%
Kenosha	154,726	3.77%
Kewaunee	125,200	3.05%
Langlade	94,138	2.29%
Manitowoc	226,813	5.52%
Marinette	107,487	2.62%
Marquette	136,511	3.32%
* Menominee	0	0.00%
Milwaukee	14,372	0.35%
Oconto	199,581	4.86%
* Outagamie	350,894	8.55%
Ozaukee	93,331	2.27%
Racine	213,560	5.20%
* Shawano	221,393	5.39%
Sheboygan	213,048	5.19%
Washington	159,698	3.89%
Waupaca	241,004	5.87%
Waushara	220,166	5.36%
Winnebago	219,406	5.34%

* denotes counties with reservations

Of the 7 lowest pesticide-using counties, 5 are counties with reservations.
In the remaining three counties with reservations: Brown, Outagamie, and
Shawano, pesticide use is in line with use in other counties in the Basin.

Aldicarb Exceedances in Wisconsin

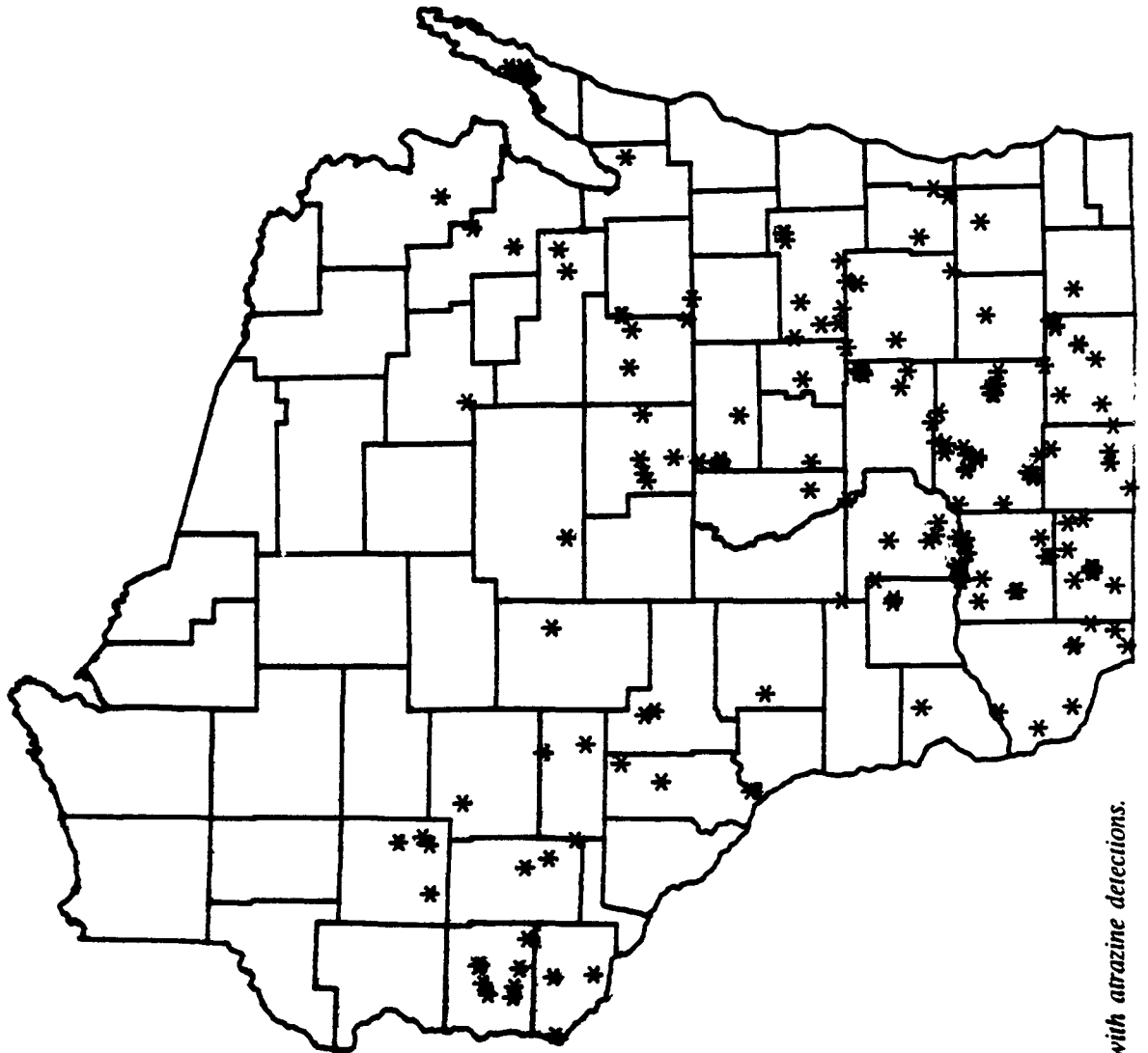
Above the Enforcement Standard



Wells with aldicarb exceeding 10 ppb.

Atrazine Detects in Wisconsin

From January 1, 1980 to January 1, 1990



Wells with atrazine detections.

Food Contamination

This paper provides information on the risks to Wisconsin Indians from consumption of harvested food. No data have been gathered relating to risks from consumption of non-harvested food -- that which is purchased from sources in general commerce. Accordingly, the risks estimated in this paper cover those from only a part of the Tribes' total diet.

DATA SOURCES

Dietary profile

The dietary profile used in the analysis is based on a paper by Don Wedll, the Mille Lacs Commissioner of Natural Resources, "Mille Lacs Band of Chippewa Indians: Basic Existence Requirements for Harvesting of Natural Resources," 1984, Revised 1986. In the absence of any other information, the dietary profile for the Minnesota Mille Lacs Native Americans is assumed to be the same as the Wisconsin tribes for the purpose of this analysis. Data on the average individual daily intake and the percent of food harvested for consumption are used to develop the average daily intake of harvested foods (see table).

For comparison with some of these data, EPA's assumed daily fish consumption by the average American is 6.5 grams. Members of the Wisconsin Tribes are assumed to consume nearly six times as much fish, 90% from local sources.

Contaminant concentrations in harvested foods

No contaminant data was available for fruits (e.g. berries), vegetables, grains (wild rice), milk products, or sweets (maple sugar).

Wild Game and Waterfowl

Contaminant data for wild game and waterfowl is from "Environmental Contaminant Monitoring in Wisconsin Wild Game, 1987," from the Bureau of Wildlife Management, Wisconsin Department of Natural Resources (DNR), August, 1988. The 120 samples in this data collection were taken from 1984 through 1987. More recent data are not available.

Waterfowl data for this analysis includes all species of waterfowl included in the DNR data, although most of the samples are for mallard ducks (68%). This analysis is based largely on samples from countries in the ceded territories. Data from Brown and Outagamie counties have been added to the sample to represent areas outside the ceded territories where the Oneida tribe may hunt. Data included in the analysis are based on muscle-only or muscle and skin samples; samples in the DNR data based on skin-only have been excluded. Duplicate samples have been excluded from the analysis as well.

The limited nature of the wild game data available from the DNR (13 small game, 14 large game) led to the use of all samples, regardless of the county of origin or type of sample. Samples included muscle-only, fat-only (for bears), muscle and fat combined, kidney, and liver (these organs were sampled for mercury, chromium, selenium, and cadmium only). Only five of the wild game samples are from counties in the ceded territories.

Fish

Concentrations of contaminants in fish tissue are from the database of the Bureau of Water Resources Management, DNR. The data used in this analysis includes the Northern and North Central Districts and includes 287 samples for 32 different fish. The data was collected from 1985 through 1990. The counties included in this data represent the ceded territories. All samples are from filets. Although a wide variety of fish species are represented among the samples, walleye and northerns are the most common. Samples where mercury was the only contaminant that was tested for have been excluded to reduce the data set to a manageable size.

A second source of mercury concentration data is the "GLIFWC Mercury Analysis 1991," from the Great Lakes Indian Fish and Wildlife Commission's 1991 Mercury Project. This analysis includes 55 samples from 23 lakes in the ceded territories, using walleye fish in all but three cases. Samples are based on skin-off filets. We did not use this data set for this analysis, as we thought the DNR data set probably more accurately represented the profile of the fish species actually consumed by the Wisconsin Native Americans.

For comparison purposes, the GLIFWC analysis would result in an average concentration of mercury (538 ug/kg) which is about 50% higher than is calculated using the DNR data (364 ug/kg).

TREATMENT OF NON-DETECT RESULTS

The analysis is based on two different assumed scenarios for the sample results that were below detection limits for a contaminant.

- 1 - Contaminant concentrations below detection limits are assumed to be zero.
- 2 - Contaminant concentrations below detection limits are assumed to be half of the detection limit.

Average concentrations, cancer risks, and non-cancer health indices are calculated for each case.

ESTIMATE OF CONTAMINANT DOSE

The daily dose of each contaminant received by a tribe member is assumed to be the average concentration in the meat, poultry, or fish multiplied by the average daily intake of the harvested food. Contaminant concentrations are averaged across all individual samples within

each of the four food groups (large game, small game, fish, and poultry) in order to determine the average contaminant concentration in each. The average amount of each food group ingested is based on the Wedll study.

CANCER AND NON-CANCER RISK CALCULATIONS

Cancer Risk and Non-cancer Health Index are calculated for each contaminant-food group pair, where concentration data is available, using Risk Assistant™ software. The calculations assume ingestion for 350 days/year for 30 years, for a 70 kg adult with a 70 year lifespan. The software uses a standard 0.054 kg/day for the daily food intake. This amount was scaled appropriately for the average daily intake amounts taken from the Wedll study. A standard Dose x Potency = Risk function is employed in the software along with access to contaminant specific risk information from IRIS (Integrated Risk Information System) and HEAST (Health Effects Assessment Summary Tables). Risks for ingested carcinogens are a function of the oral slope factor and the dose. The Health Index for Non-cancer Toxic Effects compares the predicted average daily dose to the reference dose at which no toxic effects are expected.

HEALTH RISK RESULTS

The results of these calculations are shown in separate tables for the four food groups in total and for each food group separately. The estimated health risks appear significant:

- o Total excess lifetime cancer risk for the average individual is about 4×10^{-3} . PCBs are responsible for nearly all of this risk, but several pesticides also contribute risks exceeding 10^{-6} . About half of the PCBs are estimated to come from small game, about 1/4 from large game, about 15% from fish, and about 8% from poultry.
- o Hazard indices for non-cancer effects are two orders of magnitude greater than 1 for PCBs and they exceed 1 for mercury. Three fourths of the mercury is estimated to derive from small game, 22% from fish, and 2% from poultry. No data on mercury in large game was available.

These estimates are quite uncertain for several reasons:

- o The small and large game food groups contribute a large fraction of the risk, but very few game animals have been sampled for contaminants. The small game data are particularly unreliable, as we included data on several otters in this category. Otters are at the very top of a lengthy food chain and they can be expected to bioaccumulate contaminants even more than large game fish.
- o The data sets were too limited to allow for a rigorous match between the locations where samples were taken and the locations of Indian harvesting. Similarly, it was not possible to match rigorously the parts of the animal sampled and the parts

actually eaten.

Nevertheless, the results for these four food groups clearly suggest high health risks from harvested food for Native Americans in Wisconsin.

SEVERAL ADDITIONAL POINTS

- o These calculations represent the average diet. Individuals who are particularly heavy consumers of harvested foods will experience even higher risks.
- o With no contaminant data available for harvested fruits, vegetables, grains, or sweets, we were unable to calculate any risks for these components of the diet. Some plants are known to concentrate toxic elements from their environment. If wild rice, berries, maple sugar, or other staples of the Native American diet do so also, total dietary risks for the Wisconsin tribes could be much higher than those calculated thus far.

Further information about potential health effects comes from an ongoing University of Wisconsin/Wisconsin Department of Health study of fish consumption and blood mercury levels in Wisconsin Chippewa Indians. The study has found that:

- o "Mercury levels in Chippewa Indians are directly related to how many walleyes they have eaten recently. The higher the number of walleye meals a person has eaten in the past two months, the higher the person's blood mercury is.
- o The current levels of blood mercury in the Chippewa surveyed (generally 0 - 10 ppb) are below the levels with known health effects (symptoms of mercury poisoning may begin at 80 ppb).
- o While levels are currently below the levels with known health effects, blood mercury levels could go up if:
 - People ate more fish (especially walleye)
 - People ate fish that were more contaminated (taken from more contaminated lakes)

If people did both, eating more fish and eating fish from more contaminated lakes, blood mercury levels could go up substantially."

Ongoing research is beginning to suggest some direct links between consumption of Great Lakes fish with high PCB levels and adverse health impacts. A study comparing children of women who were heavy fish consumers before pregnancy with children of non-consumers found short-term memory and attention deficiencies at birth, at 7 months, and at 4 years in the PCB-exposed children.

Daily Food Consumption Breakdown for Wisconsin Indians

Food Group	Average Daily Intake (grams)	Percent from Harvest	Average Daily Intake From Harvest (grams)
Fruits/Vegetables	225.00	50%	112.50
Grain	113.40	75%	85.05
Meat			
Large Game	67.38	90%	60.64
Small Game	20.13	90%	18.11
Fish	35.00	90%	31.50
Poultry	17.50	90%	15.75
Milk & Cheese	84.50	1%	0.85
Sweets	84.50	70%	59.15

Examples of items in each food group:

Fruits/Vegetables: Seasonal vegetables, bracken fern, asparagus
Chokecherries, june berries, blue elderberry, plums, blackberries, raspberries, blueberries, cranberries, strawberries

Grain: Wild rice, yellow pond lilly, arrowhead

Large Game: Deer (may be replaced by bear, moose)

Small Game: Rabbits, porcupines, muskrats

Poultry: Ducks, geese, coots, grouse, cranes

Fish: Walleye, northerns, perch, eelpout, suckers, sturgeon, trout

Sweets: Maple sugar

Source:

Wedll, Don, *"Mille Lacs Band of Chippewa Indians: Basic Existence Requirements for Harvesting of Natural Resources,"* 1984, Revised 1986.

Species Representing Food Groups

Food Group	Type, Species with Contaminant Data	
Fruits and Vegetables Grains Milk and Cheese Sweets (Maple sugar)	Data on the contaminants in the harvested portion of these items was not available.	
Meat	Large Game	White-tailed Deer Black Bear
	Small Game	Cottontail Rabbit Muskrat Otter Raccoon Snowshoe Hare
	Poultry (Waterfowl)	Blue-Winged Teal Canada Goose Common Merganser Green-Winged Teal Lesser Scaup Mallard Northern Pintail Northern Shoveler Pied-Billed Grebe Ringed-Neck Duck Wood Duck
	Fish	Big-Mouth Buffalo Balck Crappie Bloater Chub Bluegill Brook Trout Brown Trout Burbot Carp Channel Catfish Chinook Salmon Coho Salmon Falthead Catfish Lake Herring Lake Sturgeon Lake Trout Lake Whitefish Largemouth Bass Musky Northern Pike Northern Redhorse Rainbow Smelt Rainbow Trout Rock Bass Sheepshead/Drum Siscowett Lake Trout Smallmouth Bass Splake Walleye White Bass White Sucker Yellow Bullhead Yellow Perch

Estimated Cancer and Non – Cancer Human Health Risks in Wisconsin Indian Diet

	ALL FOOD GROUPS			
Contaminants	Non – Detects = 0		Non – Detects = Half Det. Limit	
	Cancer Risk	Non – Cancer Health Index	Cancer Risk	Non – Cancer Health Index
Mercury	0.00E+00	2.26E+00	0.00E+00	2.26E+00
PCB	3.56E-03	1.56E+02	3.67E-03	1.70E+02
Chlordane	1.75E-06	5.83E-02	2.04E-05	6.71E-01
Dieldrin	7.13E-05	2.75E-01	2.11E-04	5.00E-01
DDD	3.50E-07	0.00E+00	4.38E-06	0.00E+00
DDE	2.68E-05	0.00E+00	2.97E-05	0.00E+00
DDT	3.50E-06	4.67E-02	9.33E-06	1.31E-01
Toxaphene	1.17E-04	0.00E+00	2.33E-04	0.00E+00
Arsenic	0.00E+00	2.33E-02	0.00E+00	1.17E-01
Cadmium	0.00E+00	3.37E+00	0.00E+00	3.46E+00
Chromium	0.00E+00	0.00E+00	0.00E+00	3.09E-02
Copper	0.00E+00	1.17E-02	0.00E+00	1.17E-03
Lead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aldrin	0.00E+00	0.00E+00	5.83E-05	3.50E-01
Endrin	0.00E+00	0.00E+00	0.00E+00	1.75E-02
Pentachlorophenol	2.33E-07	1.75E-04	4.08E-07	2.92E-04
BHC	0.00E+00	0.00E+00	4.67E-06	2.63E-02
Hexachlorobenzene	2.33E-07	4.08E-04	6.13E-06	1.02E-02
Methoxychlor	0.00E+00	0.00E+00	0.00E+00	8.17E-03
2,4,5 – Trichlorophenol	0.00E+00	0.00E+00	0.00E+00	2.33E-04
2,4,6 – Trichlorophenol	5.83E-07	0.00E+00	1.17E-07	0.00E+00
Selenium	0.00E+00	9.19E-02	0.00E+00	1.31E-01
Cancer Risk Totals	3.78E-03		4.25E-03	

Estimated Cancer and Non-Cancer Human Health Risks in Wisconsin Indian Diet

FOOD GROUP: FISH						
Contaminants	Consume .0315 kg/day					
	Non-Detects = 0			Non-Detects = Half Det. Limit		
	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index
Mercury	363.969	0.00E+00	5.25E-01	364.124	0.00E+00	5.25E-01
PCB	433.745	5.83E-04	2.92E+01	487.530	5.83E-04	2.92E+01
Chlordane	8.125	1.75E-06	5.83E-02	31.042	5.83E-06	2.33E-01
Dieldrin	25.521	5.83E-05	2.33E-01	31.667	1.17E-04	2.92E-01
DDD	4.643	2.33E-07	0.00E+00	28.452	1.17E-06	0.00E+00
DDE	149.762	1.17E-05	0.00E+00	164.940	1.17E-05	0.00E+00
DDT	47.738	2.92E-06	4.08E-02	67.560	4.08E-06	5.83E-02
Toxaphene	689.655	1.17E-04	0.00E+00	1094.828	2.33E-04	0.00E+00
Arsenic	55.556	0.00E+00	2.33E-02	277.778	0.00E+00	1.17E-01
Cadmium	0.000	0.00E+00	0.00E+00	82.857	0.00E+00	5.83E-02
Chromium	0.000	0.00E+00	0.00E+00	207.143	0.00E+00	1.75E-02
Copper	755.000	0.00E+00	1.17E-02	83.556	0.00E+00	1.17E-03
Lead	0.000	0.00E+00	0.00E+00	2083.333	0.00E+00	0.00E+00
Aldrin	0.000	0.00E+00	0.00E+00	25.000	5.83E-05	3.50E-01
Endrin	0.000	0.00E+00	0.00E+00	11.071	0.00E+00	1.75E-02
Pentachlorophenol	11.282	2.33E-07	1.75E-04	18.846	4.08E-07	2.92E-04
BHC	0.000	0.00E+00	0.00E+00	7.308	1.75E-06	1.17E-02
Hexachlorobenzene	0.769	2.33E-07	4.08E-04	5.385	1.75E-06	2.92E-03
Methoxychlor	0.000	0.00E+00	0.00E+00	25.000	0.00E+00	2.33E-03
2,4,5-Trichlorophenol	0.000	0.00E+00	0.00E+00	50.000	0.00E+00	2.33E-04
2,4,6-Trichlorophenol	0.000	5.83E-07	0.00E+00	50.000	1.17E-07	0.00E+00
Selenium			5.83E-02			5.83E-02
Cancer Risk Totals		7.76E-04			1.02E-03	

SOURCE: Wisconsin Department of Natural Resources

NOTE: Blank cells indicate contaminant data was not available.

Estimated Cancer and Non-Cancer Human Health Risks in Wisconsin Indian Diet

FOOD GROUP: SMALL GAME						
Consume 0.01811 kg/day						
Contaminants	Non-Detects = 0			Non-Detects = Half Det. Limit		
	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index
Mercury	2095.000	0.00E+00	1.68E+00	2100.000	0.00E+00	1.68E+00
PCB	1929.000	1.68E-03	6.71E+01	1979.000	1.68E-03	6.71E+01
Chlordane	0.000	0.00E+00	0.00E+00	25.000	3.35E-06	1.01E-01
Dieldrin	6.000	1.01E-05	3.02E-02	13.000	2.35E-05	6.71E-02
DDD	0.000	0.00E+00	0.00E+00	25.000	6.71E-07	0.00E+00
DDE	10.000	3.35E-07	0.00E+00	30.000	1.01E-06	0.00E+00
DDT	0.000	0.00E+00	0.00E+00	25.000	1.01E-06	1.34E-02
Toxaphene						
Arsenic						
Cadmium	0.000	0.00E+00	0.00E+00	100.000	0.00E+00	3.35E-02
Chromium	0.000	0.00E+00	0.00E+00	250.000	0.00E+00	1.34E-02
Copper						
Lead						
Aldrin						
Endrin						
Pentachlorophenol						
BHC	0.000	0.00E+00	0.00E+00	5.000	6.71E-07	3.35E-03
Hexachlorobenzene	0.000	0.00E+00	0.00E+00	5.000	1.01E-06	1.68E-03
Methoxychlor	0.000	0.00E+00	0.00E+00	25.000	0.00E+00	1.34E-03
2,4,5-Trichlorophenol						
2,4,6-Trichlorophenol						
Selenium	600.000	0.00E+00	3.35E-02	662.500	0.00E+00	6.71E-02
Cancer Risk Totals		1.69E-03			1.71E-03	

SOURCE: Wisconsin Department of Natural Resources

NOTE: Blank cells indicate contaminant data was not available.

Estimated Cancer and Non-Cancer Human Health Risks in Wisconsin Indian Diet

FOOD GROUP: LARGE GAME						
Consume: 0.06064 kg/day						
Contaminants	Non-Detects = 0			Non-Detects = Half Det. Limit		
	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index
Mercury						
PCB	375.000	1.01E-03	4.49E+01	450.000	1.12E-03	5.61E+01
Chlordane	0.000	0.00E+00	0.00E+00	25.000	1.12E-05	3.37E-01
Dieldrin	0.000	0.00E+00	0.00E+00	10.000	5.61E-05	1.12E-01
DDD	0.000	0.00E+00	0.00E+00	25.000	2.25E-06	0.00E+00
DDE	77.500	8.98E-06	0.00E+00	96.250	1.12E-05	0.00E+00
DDT	0.000	0.00E+00	0.00E+00	25.000	3.37E-06	4.49E-02
Toxaphene						
Arsenic						
Cadmium	1733.330	0.00E+00	3.37E+00	1766.670	0.00E+00	3.37E+00
Chromium						
Copper						
Lead						
Aldrin						
Endrin						
Pentachlorophenol						
BHC	0.000	0.00E+00	0.00E+00	5.000	2.25E-06	1.12E-02
Hexachlorobenzene	0.000	0.00E+00	0.00E+00	5.000	3.37E-06	5.61E-03
Methoxychlor	0.000	0.00E+00	0.00E+00	25.000	0.00E+00	4.49E-03
2,4,5-Trichlorophenol						
2,4,6-Trichlorophenol						
Selenium						
Cancer Risk Totals		1.02E-03			1.21E-03	

SOURCE: Wisconsin Department of Natural Resources

NOTE: Blank cells indicate contaminant data was not available.

Estimated Cancer and Non-Cancer Human Health Risks in Wisconsin Indian Diet

FOOD GROUP: POULTRY						
Contaminants	Consume .01575 kg/day					
	Non-Detects = 0			Non-Detects = Half Det. Limit		
	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index	Avg. Conc. ug/kg	Cancer Risk	Non-Cancer Health Index
Mercury	69.540	0.00E+00	5.83E-02	77.850	0.00E+00	5.83E-02
PCB	427.450	2.92E-04	1.46E+01	549.470	2.92E-04	1.75E+01
Chlordane						
Dieldrin	2.790	2.92E-06	1.17E-02	9.430	1.46E-05	2.92E-02
DDD	4.750	1.17E-07	0.00E+00	19.510	2.92E-07	0.00E+00
DDE	199.180	5.83E-06	0.00E+00	215.660	5.83E-06	0.00E+00
DDT	16.230	5.83E-07	5.83E-03	30.980	8.75E-07	1.46E-02
Toxaphene						
Arsenic						
Cadmium						
Chromium						
Copper						
Lead						
Aldrin						
Endrin						
Pentachlorophenol						
BHC						
Hexachlorobenzene						
Methoxychlor						
2,4,5-Trichlorophenol						
2,4,6-Trichlorophenol						
Selenium	20.690	0.00E+00	0.00E+00	86.900	0.00E+00	5.83E-03
Cancer Risk Totals		3.01E-04			3.13E-04	

SOURCE: Wisconsin Department of Natural Resources

NOTE: Blank cells indicate contaminant data was not available.

Criteria Air Pollutants

This paper provides information relating to the following environmental problem areas:

13. Sulfur oxides and nitrogen oxides (including acid deposition)
14. Ozone and carbon monoxide
15. Airborne lead
16. Particulate matter

Overview

We attempted to obtain ambient air quality monitoring data for criteria pollutants for the reservations. Ambient monitoring data for the period 1985 - 1990 was obtained from EPA's Aerometric Information Retrieval System (AIRS) for monitors within reservations and within counties in which reservations are located. The Wisconsin 1989 Air Quality Data Report was also consulted for monitoring data from other areas of the state.

Very few air monitoring stations are located on reservations themselves, and these monitors cover only particulate matter. Several other monitoring stations, providing coverage for a broader set of pollutants, are in locations near reservations that we judge likely to be similar to the reservations. For several criteria pollutants, though, the only available data for Wisconsin was for sites expected to have much more severe ambient air problems than the reservations (e.g., major cities, sites near major industrial point sources). In the absence of other data, we used the data from such sites to provide an upper bound -- ambient concentrations on the reservations are almost certainly well below those found at these "worst case" sites. Even at the worst case sites, ambient concentrations of criteria pollutants rarely approached the national ambient air quality standards, and risks appear minimal.

The following table shows the ambient concentrations of criteria air pollutants that we used for the study. In some cases we obtained ambient data that are representative of the reservations. In other cases (which are noted in the table), data were available only for "worst case" sites in the state that we believe represent far worse concentrations than exist on the reservations. The table compares the observed concentrations with the NAAQS or other health-based threshold for each pollutant.

Pollutant	NAAQS	Observed Levels	Location
Particulates (PM10)	50 ug/m3, annual arith. mean	5 - 20 ug/m3	Menominee Res., Stockbridge Res., Oneida Res., Boulder Jct., Vilas Co.
Carbon monoxide (CO)	9 ppm, 8 hr avg 35 ppm, 1 hr avg	3 ppm 6 ppm	Milwaukee (worst case in state)
Sulfur dioxide (SO2)	0.140 ppm, 24 hr max	0.111 ppm 0.014 ppm	Rhineland (nearly worst case in state) Tomahawk (typical rural)
Nitrogen dioxide (NO2)	0.053 ppm, annual arith. mean	0.020 ppm	Milwaukee (worst case in state)
Ozone (O3)	0.12 ppm, hrly avg; est. < 1 exceedence	0 exceedences, Hourly avg has exceeded .1 ppm twice since 1989	Brown Co. Oneida Co. Outagamie Co. Florence Co., (typical of rural WI)
Lead (Pb)	1.5 ug/m3, qrtly arith. mean	in 1989, < 0.1 ug/m3	Milwaukee (worst case in state)
Sulfates	Health Risk thresholds: 7.0 ug/m3, hospital admissions 10.0 ug/m3, deaths, respiratory symptoms	< 3 ug/m3 < 5 ug/m3	Boulder Jct. (Vilas Co.) Green Bay, Milwaukee (worst cases in state)

Acid Deposition

While acid deposition is not directly responsible for major human health problems, it may pose significant ecological risks and perhaps social and economic damages also. Ecological effects may indirectly lead to human health risks in the case of increased mercury uptake by food fish in acidic waters.

The Great Lakes Basin Risk Characterization Study states that evidence of acid deposition is apparent in Wisconsin's lakes, but streams do not exhibit any noticeable effects. Although acid deposition continues to be a problem, the state has observed decreases in acidity of deposition in recent years accompanying decreasing SO₂ emissions. Sulfates, as opposed to nitrates, are predominantly responsible for acidity in Wisconsin's lakes.

There are a number of acid deposition monitoring sites situated across the state, and those in the north are near enough to reservations to consider their characteristic acid deposition similar to that on the reservations. Acid deposition sites in 1989 included those in: Cornucopia (near Red Cliff), Round Lake (near Lac Courte Oreilles), Trout Lake (near Lac du Flambeau), People River (near Mole Lake, Potawatomi), Suring (near Menominee), and Shawano (near Menominee, Stockbridge-Munsee). These sites are monitored under the auspices of various programs, including the National Atmospheric Deposition Program (NADP), the Great Lakes Atmospheric Deposition program (GLAD), and the Utility Acid Precipitation Study Program (UAPSP). Data is available for these sites for the years 1980-86.

Isopleth maps (for sulfates, nitrates, hydrogen ions, and pH in the years 1983-86) from Chemical Characteristics of Wet Deposition in Wisconsin 1980-86 reveal that annual average pH levels in deposition range from about 4.5 to 5.0. As one travels from the northwest of Wisconsin to the southeast, pH drops. To estimate impacts on lakes one can turn to the National Acid Precipitation Assessment Program (NAPAP) Eastern Lake Survey of lakes in the Great Lakes Basin, which provides data on pH levels in north-central Wisconsin. This 1988 study found that 414 lakes (6% of total lake area) have a pH less than 6.0. For information about potential effects by pH level see the accompanying chart.

In addition, the acid neutralizing capacity (ANC) of Wisconsin's lakes is fairly low. Nearly 40% of lakes were classified as extremely sensitive to acid deposition.

Health Risks:

The only human health risk associated with acid deposition is linked to deposition of mercury. Low pH facilitates mercury uptake by fish, posing health threats to fish-eaters. For a more in-depth discussion of this issue, see the section on mercury contamination in fish.

Ecological Risks:

Acid deposition can prompt changes in both terrestrial and aqueous ecosystems. On land,

acidity may have effects on the following processes: "foliar integrity, foliar leaching, root growth, soil properties, microbial activity in soil, resistance to pests and pathogens, germination of seeds, and establishment of seedlings" (GLB Risk Characterization study). If changes occur, they can cascade and may have more permanent effects on an entire ecosystem. Two studies in particular have been performed on important tree species in Wisconsin, sugar maple and white pine, and they noted changes most likely linked to acid deposition. In a survey of the decline and mortality of sugar maple and other northern hardwoods across Wisconsin, it was discovered that about 2% of sugar maples were experiencing decline or were dead. About 36% of these trees did not appear to be plagued by pests or disease, leaving acid deposition as the only viable cause. White pines also seem to be suffering under acid deposition. A survey of white pines revealed that many in the state are suffering from tipburn and mottling caused by dry deposition of sulfur dioxide and ozone. The problem is most severe in the southern areas of the state; however, even in the less affected northern counties, between 50 and 70% of white pines displayed premature needle loss.

Obviously, acidity can also affect natural repositories of precipitation. Wisconsin's lakes are particularly affected; pH of streams does not appear to be dropping. As was mentioned previously, 6% of lakes in northern Wisconsin have a pH of less than 6.0. At this level, some species will be lost and reproduction will be affected. Just as small increases in acidity can affect terrestrial ecosystems, they can also disrupt aquatic ones, by inhibiting diversity, leading to overgrowth of dominant species. If acidity becomes extreme (i.e. pH is less than 4.2) lakes will become lifeless.

Acid deposition, in addition to direct effects, can pose additional threats when combined with other problems. As previously stated in the health effects section, acidic waters can facilitate mercury uptake by fish. Not only can eating such fish induce adverse health effects in humans, it can also affect the health and reproductive success of various fish-eaters, such as bald eagles, osprey, loons, and furbearers (WI Acid Deposition Monitoring and Evaluation Program 1989-90). A study referred to in the GLB Risk Characterization study identified the heightened effects produced by the combination of acid deposition and ozone, including leaching of nutrients from plant tissue and the soil.

Economic and Social Damages:

Acid deposition probably contributes to the following categories of losses:

- o Timber revenues lost through forest die-back
- o Reduction in sport and commercial fisheries
- o Cultural losses with effects on bald eagle, other animals, healthy ecosystem in general
- o Accelerated deterioration of outdoor materials

Particulates

Data was available from monitors on or near four reservations: Menominee, Stockbridge-Munsee, Oneida, and Lac du Flambeau. However, with the exception of the Oneida data, only total suspended particulates (TSP) figures were available. After identifying the relationship between TSP and particulate matter smaller than 10 mm (PM10) for sites at which both were monitored, PM10 levels for the reservations were estimated by adjusting the monitored TSP levels. The estimated PM10 levels on the reservations were half or less of the National Ambient Air Quality Standards (NAAQS).

Health risks:

The estimated PM10 levels were well below the threshold levels at which adverse health impacts might be expected. According to Region 5's formula for calculating excess mortality from particulates, deaths are possible when PM10 levels exceed 150 ug/m³ on at least one day of the year. The highest PM10 concentration estimated at a reservation on any day was 52 ug/m³ (Oneida). Restricted activity days may be possible when the annual average PM10 concentration exceeds 38 ug/m³. The highest annual average PM10 concentration at a reservation was estimated at 21 ug/m³ (Oneida). In fact, no site anywhere in Wisconsin recorded PM10 levels exceeding either of these thresholds.

Ecological risks:

No ecological risks are expected from particulate concentrations at these levels.

Economic and social damages:

Applying Region 5's formula for materials damage (soiling, etc.) to TSP concentrations on the reservations results in annual estimated losses of \$40,000.

Sulfur Dioxide

We obtained no monitoring data for sulfur dioxide in or very near reservations, although some monitoring was evidently performed for the Oneida reservation in 1989-1991. However, both AIRS and Wisconsin state data lead to the conclusion that ambient sulfur dioxide poses minimal risks on the reservations. In the 1989 Wisconsin data for sulfur dioxide, there were no exceedences of the NAAQS and only two of 22 sites came within 20% of the NAAQS. The remainder of the sites reported levels at less than half of the ambient standard. One of the two sites which neared the standard is located in Rhinelander, about 30 miles from both the Lac du Flambeau and Mole Lake reservations. It is questionable whether concentrations in Rhinelander extend to the reservations, however, as high SO₂ concentrations are usually very localized around point sources. SO₂ concentrations in Rhinelander have not actually exceeded the NAAQS since 1985.

Sulfates -- Health risks

Ambient sulfate levels are not high enough to pose any significant risk to individuals living on reservations. Wisconsin's report on atmospheric sulfate levels for 1987-88 assumes that the Boulder Junction monitoring site in Vilas county provides information about background levels of ambient sulfates for rural areas in the state. This site is located in northern Wisconsin and may be assumed to be representative of the reservations. The two other sites monitored, in Milwaukee and the Green Bay - Fox River Valley, were assumed to exhibit the highest ambient sulfate levels in the state. Annual average sulfate levels at all three sites fell well below the threshold levels at which Region 5 believed that adverse health impacts might begin to occur. The levels at Boulder Junction were particularly low.

Nitrogen Oxides

No monitoring data is available for nitrogen oxides in or very near reservations. Wisconsin monitors nitrogen oxides at four urban sites, and at none of them did 1989 concentrations approach the NAAQS. NO_x concentrations are typically localized around major point sources of fossil fuel combustion such as utilities and industrial facilities. There are few such facilities near reservations, and we would expect concentrations on the reservations to be substantially lower than at any of the four state monitoring sites. The Region 5 comparative risk report indicates that there are no non-attainment areas for NO_x in the entire Region. We expect no health, ecological or economic risks from NO_x on the reservations.

(The Region 5 report calculates annual economic damages from NO_x relating to fading of dyes. Their formula assumes damages at a flat rate of \$1.20/person. We do not believe this formula should be applied to the reservations, as NO_x concentrations there are probably so low as to make inappropriate this per person assumption.)

Ozone

Ozone is monitored at several dozen sites in Wisconsin, none of which are in reservations. Three sites are in counties in which reservations are located (Oneida County, Green Bay in Brown County, and Appleton in Outagamie County). The ozone NAAQS has been exceeded only once in the last five years at these sites, and all three counties are counted as being in attainment with the standard.

Wisconsin does have many areas that do not attain the ozone NAAQS, but these areas are generally just north of the Illinois border or downwind of Milwaukee. The state considers one of its sites (People River, in Florence County) to provide concentration data that is typical of the rural areas of the State outside of the southeast. Ozone concentrations at this site in 1989 reached .104 ppm on one day, and were otherwise below .1 ppm, well within the NAAQS.

We assume that ozone concentrations on Wisconsin reservations are like those at the

Oneida, Brown, Outagamie and Florence County sites.

Health risks:

Region 5 took the conservative position that adverse health impacts (asthma attacks and respiratory restricted activity days) might be experienced from ozone concentrations as low as .1 ppm, below the ambient standard of .12 ppm. Ozone concentrations at the four Wisconsin sites we assume as representative of the reservations have exceeded .1 ppm at most once per year for the past several years. We expect no adverse health impacts from ozone on the reservations.

Ecological risks:

Research at the University of Wisconsin has indicated that concentrations of ozone as low as .06 ppm can have an impact on photosynthetic production of important crop and forest species, such as white pine, soybeans, clover and alfalfa. Faster growing farm crops and sensitive tree species (American sycamore, loblolly pine, pitch pine, white pine and green ash) are at particular risk. In the field, damage to tree species from ozone is difficult to distinguish from that due to acid deposition. For the most part, damage from air pollution to white pine, sugar maple and other hardwoods in northern Wisconsin appears small. See the discussion of acid deposition impacts for more information.

Economic and social damages:

Region 5 estimated region-wide crop losses from ozone at 7% for soybean production and 12 % for wheat production. Research underlying these estimates indicates that the loss rates are far higher in the southern areas of Region 5 than in the northern areas. We roughly estimate crop losses from ozone concentrations on the reservations at less than 5% of the annual value of production.

Region 5 also estimated that ozone causes annual damages of \$.94 per person by necessitating addition of anti-ozonants to sensitive materials (e.g., tires). Since these costs have been borne by every person purchasing such consumer goods regardless of the actual ozone levels where they live, we have used this figure for the Tribes as well.

Carbon Monoxide

Although no monitoring data is available for carbon monoxide in or near reservations, it appears very unlikely to be a problem there. Nationally this pollutant occurs in high concentrations usually only in localized areas of high vehicular traffic density -- conditions that will not prevail on reservations. Wisconsin monitors CO at 9 urban sites, and concentrations are well below the NAAQS at all but one of them (Oshkosh, with an unusual combination of vehicular traffic and industrial point sources of CO). No health, ecological or economic damages are expected from CO on the reservations.

Lead

Airborne lead poses little or no risk to individuals residing on reservations. Both the Region 5 Comparative Risk study and the state of Wisconsin Air Quality Data Report state that airborne lead is not a major problem in Wisconsin. The Region 5 study reported that in the entire region, only 4 sites violated the ambient lead standard and that these sites were all located in major cities. Wisconsin conducted monitoring in the city of Milwaukee's most heavily-trafficked areas and found that levels in recent years are only about 5% of the NAAQS.

SOURCES

Great Lakes National Program Office. Great Lakes Basin Risk Characterization Study. Preliminary. 29 April, 1991.

U. S. Environmental Protection Agency, Region 5. Great Lakes Atmospheric Deposition (GLAD) Network, 1982 and 1983.

U. S. Environmental Protection Agency. Aerometric Information Retrieval System (AIRS) data, 1985-90.

Wisconsin Department of Natural Resources. Atmospheric Sulfate Levels in Wisconsin: 1985-1986. May 1988.

Wisconsin Department of Natural Resources. Chemical Characteristics of Wet Deposition in Wisconsin, 1980-1986. March, 1989.

Wisconsin Department of Natural Resources. 1989 Wisconsin Air Quality Data Report.

Wisconsin Department of Natural Resources. 1989 Sulfur Dioxide and Nitrogen Oxide Emissions Report. March 1991.

Wisconsin Department of Natural Resources. Wisconsin Acid Deposition Monitoring and Evaluation Program, 1989-90 Annual Report. January 1991.

pH levels in NAPAP Eastern Lake Survey Lakes in the Great Lakes Basin

		Northeast Minnesota	Upper Peninsula of Michigan	North Central Wisconsin	Upper Great Lakes	Adirondacks
pH ≤ 5.0	Number of Lakes	0	95	30	0	129
	Percent of Lake Area	0 %	2 %	0.5 %	0 %	2 %
	Area in Hectares (Acres)	0	680 (1,680)	0	0	2,380 (5,880)
pH ≤ 5.5	Number of Lakes	0	137	163	0	258
	Percent of Lake Area	0 % ¹	3 %	2 %	0 %	8 %
	Area in Hectares (Acres)	0	1,200 (2,520)	1,960 (4,843)	0	9,520 (23,500)
pH ≤ 6.0	Number of Lakes	14	189	414	180	348
	Percent of Lake Area	0 % ¹	5 %	6 %	1 %	10 %
	Area in Hectares (Acres)	0	1,700 (4,200)	5,880 (14,530)	2,270 (5,610)	11,900 (29,400)

Source: NAPAP. 1988. NAPAP Interim Assessment: The Causes and Effects of Acidic Deposition.
Volume IV: Effects of Acidic Deposition.

Notes on Effects of Acidification on Freshwater Aquatic Ecosystems

pH	Effect
7.0	Reduced reproduction in most sensitive species (<u>Daphnia</u>)
6.6	First species lost (snails)
6.1	Reduction in zooplankton species
6.0	Loss of <u>Daphnia</u> , reduction in crayfish species
5.9 - 5.8	First fish species lost
5.8 - 5.7	Major crustaceans lost
5.6	First substantial change in phytoplankton density, crayfish lost
5.5	Most species of rotifers lost
5.5 - 5.0	Large reduction in decomposition rates
5.5 - 4.7	Most fish species lost
4.7	Major reduction in phytoplankton density
4.7 - 4.6	Major reduction in zooplankton density
4.2	Last fish species lost

Hazardous/Toxic Air Pollutants

This paper provides information relating to environmental problem area # 17, Hazardous/Toxic Air Pollutants.

Available Data

Very little ambient monitoring data for toxic air pollutants is available that is representative of conditions on the reservations. The bulk of Wisconsin's air toxics monitoring has occurred in Milwaukee. We obtained three limited sets of air toxics data for the reservations:

1. Six samples taken at Keshena on the Menominee Reservation between 11/89 and 7/90 in which suspended particulate matter was analyzed for component metals. The results from these samples are shown in Table 1.
2. A number of samples taken on the Oneida, Menominee and Stockbridge-Munsee Reservations for atrazine, PCBs and Benzo-(a)-pyrene in 1989 and 1990. None of these compounds were detected in these samples.
3. Air toxics monitoring at the Fort Howard Paper waste site abutting the Oneida Reservation in September, 1986. The maximum concentrations observed across all the locations at which sampling was conducted are shown in Table 2. Additional monitoring data obtained recently for the site Remedial Investigation has not yet been analyzed.

Monitoring Results and Calculated Health Risks

Table 1: Metals in ambient air at Keshena

<u>Metal</u>	<u>Ambient Conc. (ug/m³)</u>	<u>Lifetime Avg. Cancer Risk</u>	<u>Non-Cancer Hazard</u>
Aluminum	3.0×10^{-2}	-----	-----
Barium	9.7×10^{-4}	-----	2.0×10^{-3}
Cadmium	9.0×10^{-5}	7.0×10^{-8}	-----
Chromium	2.2×10^{-4}	1.0×10^{-6} *	1.0×10^{-1}
Copper	8.5×10^{-4}	-----	-----
Zinc	9.1×10^{-4}	-----	-----
Lead	2.5×10^{-4}	-----	(4 orders of magnitude < NAAQS)

* Assuming that all the chromium found was hexavalent. This is an extremely conservative assumption, as usually nearly all chromium is in the non-carcinogenic trivalent state.

Table 2: Air toxics near Fort Howard Site

<u>Chemical</u>	<u>Ambient Conc. (ppb)</u>	<u>Lifetime Avg. Cancer Risk</u>	<u>Non-Cancer Hazard</u>
Acetone	104	-----	-----
Toluene	26	-----	5×10^{-2}
Methylene Chloride	17	1×10^{-5}	2×10^{-2}
Benzene	23	3×10^{-4}	-----

Note -- These are the maximum concentrations found at any sampling point during the Fort Howard monitoring program. The average concentrations found were substantially less.

Health Risks:

Health risks from air toxics on the reservations appear to be quite low.

The metals levels on the Menominee Reservation (Table 1) are perhaps representative of the more centrally located reservations. Average individual lifetime cancer risks here appear to be less than 1×10^{-6} . Non-cancer hazard indices are much less than one, so non-cancer effects are very unlikely. Concentrations and risks on the more isolated northern reservations are likely to be lower.

The inability to detect atrazine, PCBs or benzo-(a)-pyrine on the reservations is significant. Atrazine is the second most commonly detected pesticide in ground-water monitoring in Wisconsin. PCBs are frequently found at worrisome levels in Wisconsin fish and game. Benzo-(a)-pyrine is a common air toxic that marks products of incomplete combustion from industry, transportation, or other urban sources. The inability to detect any of these compounds suggests insubstantial emissions by agriculture, industry, transportation or households in the vicinity of the three reservations where sampling occurred.

The Fort Howard site is perhaps the worst case source of VOCs on or very near any Wisconsin reservation. Air toxics concentrations near this site are undoubtedly a substantial overestimate of the levels prevailing throughout the reservations generally. The monitored concentrations may also reflect the influence of the nearby Green Bay airport, further making this data atypical of the reservations in general. At a maximum of 3×10^{-4} , the average individual lifetime cancer risks at the worst point near even this worst case site are only moderate. Non-cancer risks near this worst case site appear minimal.

Air deposition of toxic compounds to surface water (e.g., PCBs and mercury that bioconcentrate in game fish) are counted in the "Nonpoint Sources" problem area. Air deposition to land, but not subsequent runoff to surface waters, is considered here.

Ecological Risks:

These ambient concentrations of air toxics would pose trivial risks to ecosystems.

However, deposition of air toxics over a substantial period of time appears to account for the great majority of toxics loadings to the upper Great Lakes, and substantial ecological damage.

It is unclear whether air deposition is a similar major contributor to levels of toxic compounds in inland lakes. We would speculate that air deposition is the major contributor of some anthropogenic chemicals (e.g., PCBs), and a less important contributor of other anthropogenic chemicals. Mercury in inland lakes appears to derive largely from air deposition. For some naturally occurring toxic chemicals (e.g., mercury, aluminum), acidification of inland lakes that accelerates natural leaching and/or uptake of toxic chemicals by fish may also be important (see the acid deposition discussion).

Note, however, that for this project, air deposition of toxic chemicals is defined as covered by the nonpoint sources problem area.

Social and Economic Damages:

Aside from the possibility that air toxics contribute to whatever odor problems exist on reservations, we are aware of no plausible mechanism by which toxic air pollutants could cause substantial social or economic damages.

Indoor Air Pollutants Other than Radon

Unfortunately, we have no information bearing directly on risks to the Wisconsin tribes from this issue. We relied on a national study on indoor air pollutants prepared by the Regional and State Planning Branch for our basic evaluation of the risks associated with this problem (attached). This analysis, together with circumstantial evidence, however, points to the possibility that health risks from this source may be very substantial.

- o In most risk studies of indoor air pollution, environmental tobacco smoke is the single greatest source of risk. (This references "passive smoking" only -- the effects of smoking on those other than the smoker.) The fraction of the Wisconsin Indian population that smokes is substantially higher than the fraction of the general American population that does so. One estimate from an IHS official is that perhaps 3/4 of the adult Indian population in Wisconsin smokes, compared with about 38 % of adult Indians nationwide and 26 % of all American adults.

- o Another very significant source of indoor air pollution is home heating. Indian homes in Wisconsin are disproportionally heated (more than 50%) by wood burning, the form of heating that produces the highest indoor air pollution risks. Use of kerosene and other unvented space heaters is also probably common on Indian reservations.

- o The heating season is far longer in northern Wisconsin than is typical in the rest of the U.S.

- o Indian homes are generally newer and probably more airtight than the average homes in the U.S., providing less ventilation and opportunity for exchange of cleaner outdoor air for polluted indoor air.

We strongly recommend that a careful effort be undertaken to assess the levels and risks of indoor air pollution in Indian residences.

**EPA Comparative Risk Study
Indoor Air Quality Health Risk Assessment
Region 5**

EXECUTIVE SUMMARY

This analysis identifies and, for several compounds, estimates the risks posed to human health attributable to indoor air pollutants. The estimates indicate only the general range of risk to the public in sufficient detail for comparing against other environmental problems. Although these estimates are based on generally accepted toxicity, exposure, and risk characterization methodologies, the results are not appropriate for other purposes.

In addition to many health effects not quantified here, estimates of the likely range of individual lifetime risks and population risks from cancer due to indoor air pollutants in Region 5 are as follows:

Individual Lifetime Risk of Cancer ~ 4×10^{-3} to 2×10^{-2}
(4 in 1,000 to 2 in 100)
Population Risk of Cancer ~ 800 to 10,200 excess cases per year

These risks are caused primarily from environmental tobacco smoke (ETS), asbestos, and several volatile organic compounds (VOCs): formaldehyde, benzene, carbon tetrachloride, chloroform, and tetrachloroethylene. Among the noncancer effects, the most important appear to be a miscellany of respiratory problems known collectively as sick building syndrome (SBS) and a heightened sensitivity to chemicals known as multiple chemical sensitivity (MCS). Few data exist for these conditions, but MCS creates severe physical reactions and limitations and some believe that SBS is widespread (affecting approximately 20 percent of office buildings).

DESCRIPTION OF PROBLEM

People spend up to 90 percent of their time indoors.¹ With technological changes in the chemical, manufacturing, and construction industries, thousands of potentially dangerous pollutants have been introduced into the indoor environment. Energy conservation standards and practices have produced a large portion of our current building stock that are more effectively sealed but that may not provide adequate air to dilute or purge these indoor pollutants.² A result of these and other possible causes (such as smoking), concentrations for several pollutants have been found to be twice to five times more concentrated in indoor air than outdoor air.³ The health effects of exposure to indoor pollutants have been reported to vary from mild irritation to cancer and subsequent death.

The base of available information is growing, but the multi-disciplinary and multiple chemical nature of indoor air quality (IAQ) issues makes comprehensive research difficult. There are no ecological effects that can be associated with indoor air pollutants and, therefore, no ecological risk assessment for this problem area was conducted. This analysis first discusses cancerous effects, followed by discussions of noncancerous effects.

CANCER EFFECTS

Contaminants in indoor air can cause cancer (Table 1). Because the methods used to estimate effects differ, this section is organized by contaminant (VOCs and PAHs, pesticides, ETS, and asbestos). The discussion of each group of contaminants includes a summary of the toxicity of the compounds, common exposures, and a characterization of individual risks and population risks.

Table 1. Health Effects and Sources of Indoor Air Pollutants

Pollutant	Substantiated Sources	Associated Health Effects					Reference
		Cancer	Neuro	Respir	Liv/Kid	Devel	
VOCs							
Benzene	Auto Exhaust, ETS, Fuels Fumes Adhesives, Paint Remover, Building Materials, Photo Processing Chemicals	A	X	X	X	X	A & S 1986
Formaldehyde	Building Materials, Combustion Appliances/Heaters/Engines, Adhesives Carpeting, ETS, Home & Office Furnishings, Auto Exhaust	B1	X	X		X	USEPA 1987
Chloroform	Water, Clothes Washer, Adhesives foam insulation inks	B2	X		X		A & S 1986
Carbon Tetrachloride	Grease Cleaners Adhesives Foam Insulation, Inks	B2	X		X		USEPA 1984
1,2-Dichloro- ethane	Adhesive, Foam Insulation, Tape	B2			X		Cornish 1980
Trichloro- ethylene	Adhesives, Foam Insulation Inks Photo Processing Chemicals Tape Coatings, Lubricants, Rubber	B2	X		X		Cornish 1980
Tetrachloro- ethylene	Dry Cleaning, Adhesives, Foam Insul- ation, Inks	B2	X				Cornish 1980
Benzo(a)Pyrene	ETS, Building Materials, HVAC Systems Combustion Appliances/Heaters/Engines Cleaners and Waxes, Pesticides Adhesives Paints and Supplies	B2	X		X		EPA 1989
Pesticides							
Aldrin	Insecticide, withdrawn from U.S.	B2			X		EPA 1988 1990
Alpha-BHC	Insecticide; banned in U.S.	B2			X		EPA 1988 1990
Chlordane	Insecticide; withdrawn in 1986	B2			X		EPA 1988 1990
Dieldrin	Insecticide; withdrawn from U.S.	B2			X		EPA 1988 1990
Heptachlor	Insecticide	B2			X		EPA 1988 1990
Proxpur	Insecticide; common indoor use				X		EPA 1988 1990
4,4'-DDE	Insecticide	B2			X		EPA 1988 1990
Asbestos							
Chrysotile	~95% of all asbestos found in buildings	A		X			EPA 1985
Amosite	Second most common found in buildings	A		X			EPA 1985
Crocidolite	Used only for high temperature applications	A		X			EPA 1985
ETS	Tobacco Smoking		X	X			EPA 1989 S & S 1983
Biological Contaminants	Viruses, bacterium, molds, insect and arachnid excreta, pollen, animal and human dander			X			EPA 1989
Carbon Monoxide	Combustion Gases, ETS, Auto Exhaust		X	X			Ammann undated
Sulfur Dioxide	Combustion of fuels containing sulfur			X			EPA, 1987 Ammann undated
Nitrogen Dioxide	Combustion Appliances, ETS			X			Admur 1986 Ammann undated

Key: CarEPA weight-of-evidence carcinogenicity rating

A= Known human carcinogen

B1= Probable human carcinogen (limited human data)

B2= Probable human carcinogen (no human data)

C= Possible human carcinogen

X= Reported health effect

Neuro= Neurological impairment

Respir= Respiratory impairment including asthma

Liv/Kid= Liver and/or Kidney dysfunction

Devel= Developmental problems including reproductive and congenital

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VOCs

Toxicity Assessment

The characteristics of VOCs in the indoor environment are poorly understood. Hundreds of VOCs are commonly detected in the indoor environment and several are classified as Group A or B human carcinogens.⁴ The compounds considered here were selected because they were frequently reported, usually occur in substantially higher concentrations indoors than outdoors, and they had readily available, pertinent data. Only one polycyclic aromatic hydrocarbon (PAH), Benzo(a)Pyrene, was selected because of the relative insignificance of PAHs as a group to the analysis and because of insufficient data on other PAHs. The group of VOCs commonly referred to as phthalate esters were also not included because of the lack of sufficient exposure data and the apparent insignificant contribution of the group to the risk analysis. The compounds selected for analysis and their corresponding cancer potency factors are listed below in order from highest to lowest toxicity.

<u>Compound</u>	<u>Cancer Potency Factor</u>	<u>Compound</u>	<u>Cancer Potency Factor</u>
Benzo(a)Pyrene ⁵	11.5	Tetrachloroethylene ⁵	0.051
Carbon tetrachloride ⁵	0.13	Formaldehyde ⁶	0.038
1,2-Dichloroethane ⁵	0.091	Benzene ⁵	0.029
Chloroform ⁵	0.081	Trichloroethylene ⁵	0.011

Exposure Assessment

The range of concentrations used in the analysis are listed below. This analysis identifies likely exposure levels rather than worst-case or extreme exposures. The range of concentrations used, therefore, generally reflect the differences between median and mean values reported in published studies rather than the full range of maximum and minimum values.⁸ They are listed from highest to lowest concentrations.

<u>Compound</u>	<u>Concentration Range</u>	
	<u>Low</u>	<u>High</u>
Formaldehyde	8	424
Benzene	2	204
Carbon tetrachloride	0	45
Chloroform	0.1	44
Tetrachloroethylene	5	18
Trichloroethylene	1	13
1,2-Dichloroethane	1	12
Benzo(a)Pyrene	0.001	0.003

In determining individual exposure, this analysis assumes an inhalation rate of 23 m³/day and an average person's weight as 70 kg⁹.

Risk Characterization

This analysis uses some common exposure information and generally applies those exposures on a 24-hour basis to all residents in the region. Assuming exposures are for 24 hours is reasonable considering that 80 to 90 percent of an individual's time is spent in an indoor environment. This analysis does not attempt to rigorously account for differences in exposures by location (homes, offices, and schools, for example) or to distinct groups (sensitive populations, for example), or to account for the hundreds of chemicals found in indoor air. Individual risks and annual population risks are calculated using the following equations.

$$\text{Individual Lifetime Risk} = \text{concentration (ug/m}^3\text{)} \times \text{inhalation rate (23m}^3\text{/day)} + 1000 \text{ (ug/mg)} + 70 \text{ (kg/person)} \times \text{cancer potency (mg/kg-day)}^{-1}$$

$$\text{Population Risk} = \text{individual lifetime risk} \times 46.378 \text{ million (Region 5's population)} + 70 \text{ years (average life expectancy)}$$

The results are shown below:

Compound	VOCs and PAHs			
	Individual Risk (lifetime risk)		Population Risk (annual excess cancer cases)	
	Low	High	Low	High
Formaldehyde	1 x 10 ⁻⁴	5 x 10 ⁻³	66	3507
Benzene	2 x 10 ⁻⁵	2 x 10 ⁻³	13	1288
Carbon tetrachloride	0	2 x 10 ⁻³	0	1274
Chloroform	3 x 10 ⁻⁶	1 x 10 ⁻³	2	776
1,2-Dichloroethane	3 x 10 ⁻⁵	4 x 10 ⁻⁴	20	238
Tetrachloroethylene	8 x 10 ⁻⁵	3 x 10 ⁻⁴	56	200
Trichloroethylene	4 x 10 ⁻⁶	5 x 10 ⁻⁵	2	31
Benzo(a)Pyrene	4 x 10 ⁻⁶	1 x 10 ⁻⁵	3	8

PESTICIDES

The data and methodology used for estimating lifetime individual risk for pesticides in indoor air is adopted from the Nonoccupational Pesticide Exposure Study (NOPES) published by the U.S. EPA in January 1990. Pesticides are commonly detected in indoor air. We include several pesticides that have been withdrawn, suspended, or banned because they are expected to remain in indoor air for decades.

Toxicity Assessment

Potency Factors are taken from the Integrated Risk Information System (IRIS).

<u>Pesticide</u>	<u>Cancer Potency Factor</u>	<u>Pesticide</u>	<u>Cancer Potency Factor</u>
Aldrin	17.0	Chlordane	1.3
Dieldrin	16.0	4 4' DDE	0.34
alpha-BHC	6.3	Proxpur (Baygon)	0.0079
Heptachlor	4.5		

Exposure Assessment

The range of concentrations to be used in the analysis are listed below and are from studies of Jacksonville, FL and Springfield, MA.¹⁰

<u>Pesticide</u>	<u>Concentration Range</u> (ug/m ³)		
Chlordane	197.1	to	198.7
Proxpur (Baygon)	15.0	to	185.2
Heptachlor	27.2	to	115.2
Aldrin	0.1	to	26.0
Dieldrin	0.8	to	6.4
4 4' DDE	0.6	to	3.8
alpha-BHC	0.2	to	0.8

An additional calculation allowed for a 2-year half-life of the cyclodiene termiticides (Heptachlor, Aldrin, Dieldrin, and Chlordane) that have been banned, withdrawn, or suspended. Although it is not known at what rate these pesticides degrade, this assumption helps identify the potential low end of the range for these compounds. The NOPES study assumed an inhalation rate of $21\text{m}^3/\text{day}$.

Risk Characterization

The range of estimates for lifetime individual risks as reported in the NOPES study follow, along with estimates of the number of annual excess cancer cases to the population of Region 5.

Pesticide	Individual Risk (lifetime risk)		Population Risk (annual excess cancer cases)	
	Low	High	Low	High
Heptachlor	1×10^{-6}	2×10^{-4}	1	133
Aldrin	2×10^{-8}	1×10^{-4}	0.01	66
Chlordane	3×10^{-6}	7×10^{-5}	2	46
Dieldrin	1×10^{-7}	3×10^{-5}	0.1	20
alpha-BHC	4×10^{-7}	2×10^{-6}	0.3	1
4 4' DDE	6×10^{-8}	4×10^{-7}	0.04	0.3
Proxpur (Baygon)	3×10^{-8}	4×10^{-7}	0.02	0.3

ENVIRONMENTAL TOBACCO SMOKE (ETS)

This analysis uses direct estimates of individual lifetime risk and population risk. The toxicity and exposure assessment sections, below, provide additional information but are not used in calculating risks.

Toxicity Assessment

Environmental Tobacco Smoke (ETS) causes a variety of health effects including lung cancer, cardiovascular effects, increased susceptibility to infectious diseases in children, chronic and acute pulmonary effects in children, mucous membrane irritation, and allergic reactions.¹¹ The cancer risk associated with ETS for nonsmokers has been estimated at 5×10^{-5} cancer deaths per person per mg of tobacco exposure per day.^{12,13,14} (Note that these are the estimated cancer deaths, compared to estimated cancer cases for the other compounds analyzed.)

Exposure Assessment

Due to the complex chemical composition of ETS, exposure studies generally focus on one component of ETS (tar) and report that nonsmokers are typically exposed to 1.4 mg of tar daily.¹⁵

Risk Characterization

One study's estimate of the lifetime risks of lung cancer death from ETS is between 4×10^{-3} and 1×10^{-2} for nonsmokers and only slightly higher for ex-smokers.¹⁶ The same study estimates that the annual number of lung cancer deaths from ETS is between 2,500 and 5,200 nationally, depending on the methodology used. To estimate the number of deaths in Region 5, this analysis uses the midpoint of that range, 3,850 (a number also close to an estimate in a recent EPA review draft report), and Region 5's share of the national population (46.378 million ÷ 275.7 million or 16.8%). The annual number of lung cancer deaths in Region 5 attributable to ETS is, therefore, $3,850 \times 16.8\%$ or 648.

ASBESTOS

Asbestos is the collective name given to two groups of naturally occurring mineral fibers found in various rock formations. The two groups being amphibole (amosite, crocidolite, etc.) and serpentine (chrysotile). For decades prior to 1973, asbestos was the material of choice for a wide variety of thermal, acoustical, and abrasive applications because of its unique properties. Asbestos containing materials (ACM) are found in cement products, acoustical plaster, fireproofing textiles, wallboard, ceiling tiles, vinyl floor tiles, thermal system insulation, and numerous other materials.¹⁷

Toxicity Assessment

Asbestos is classified by the EPA Science Advisory Board (SAB) as a Group A known human carcinogen.¹⁸ Asbestos-related diseases include: lung cancer, mesothelioma, and asbestosis.¹⁹ In general, dose-response data have relied heavily on occupational exposure information from various asbestos-related industries. Extrapolation of the relationship between exposure and disease indicates that only a small proportion of people exposed to low levels of asbestos will develop asbestos-related diseases. Subpopulations at greatest risk (other than those occupationally exposed) are: smokers, children, and young adults.

EPA has reported the unit risks of lung cancer and mesothelioma from asbestos exposure. These two cancers are by far the most important causes of death among exposed individuals. (Note that these are the estimated cancer **deaths**, compared to estimated cancer cases for the other compounds analyzed.)

<u>Population</u>	Lifetime Unit Cancer Risk ²⁰ (per 0.01 fibers/ml)	
	<u>Mesothelioma</u>	<u>Lung Cancer</u>
Female Smokers	2.52 x 10 ⁻³	1.50 x 10 ⁻³
Female Nonsmoker	2.72 x 10 ⁻³	1.64 x 10 ⁻⁴
Male Smokers	1.81 x 10 ⁻³	2.38 x 10 ⁻³
Male Nonsmokers	2.20 x 10 ⁻³	1.85 x 10 ⁻⁴

Exposure Assessment

EPA surveys estimate that, nationally, 31,000 (~35 percent) schools and 733,000 (~20 percent) office buildings contain ACM in varying states of disrepair.²¹ The ACM in these buildings can be classified as friable (ACM with a high probability of fiber release when disturbed) or nonfriable. The average lifetime exposure to asbestos in indoor environments have typically been reported at 0.01 fibers/ml.²² There are several studies of schools done in the late 1970s and early 1980s that showed vastly higher concentrations. These studies, however, were before the 1986 Asbestos Hazard Emergency Response Act (AHERA) was adopted into law. AHERA required Local Education Agencies (LEAs) to carry out initial response actions and have implemented an asbestos management plan in public and private schools by July 1989. We assume that most LEAs have complied with this regulation and have either removed all friable and nonfriable ACM or have it under a strict management plan that should prevent any future significant fiber release episodes. To date, Federal regulations have not required AHERA be applied to other buildings. For these reasons, these early school studies are omitted from our analysis. This study uses 0.01 fibers/ml as the upper range of exposure.

The lower limit for typical concentrations (0.0004 fibers/ml) is an arithmetic mean of several studies of public buildings. The estimate for average nonoccupational exposure concentration is, therefore, between 0.0004 and 0.01 fibers/ml.

Risk Characterization

The lifetime individual risks of death from mesothelioma and lung cancer for nonoccupational exposures to airborne asbestos fibers are shown below.

Asbestos Individual Lifetime Cancer Risk

Population	Low (0.0004 fibers/ml)		High (0.01 fibers/ml)	
	Mesothelioma	Lung Cancer	Mesothelioma	Lung Cancer
Female Smokers	1×10^{-4}	6×10^{-5}	3×10^{-3}	2×10^{-3}
Female Nonsmoker	1×10^{-4}	7×10^{-6}	3×10^{-3}	2×10^{-4}
Male Smokers	7×10^{-5}	1×10^{-4}	2×10^{-3}	2×10^{-3}
Male Nonsmokers	9×10^{-5}	7×10^{-6}	2×10^{-3}	2×10^{-4}

The estimate of individual lifetime risk, therefore, is between 7×10^{-6} and 3×10^{-3} and population risk is between 5 and 1988 cases per year.

NONCANCER EFFECTS

Humans are known to respond to indoor air pollutants in a variety of ways (Table 1). The actual response of an individual depends on at least the following: the individual's tolerance limits, the type of pollutants in the air, the exposure or dose and the number of exposures, the target organ(s) potentially affected, the rate of absorption and excretion by the body, and the rate of metabolism. A precise understanding in the scientific community of these effects and their causes is lacking, partly because the pollutants appear in complex mixtures in indoor air.

Typically, the health of most people is not severely threatened by noncarcinogenic exposures to low levels of indoor contaminants. The efforts are usually limited to discomfort or mild illness but include the following (with the reported percent of people in problem buildings reporting these conditions):

- Eye irritation (23²³ to 81%²⁴)
- Dry throat (35²³ to 71%²⁴)
- Headache (31²³ to 86%²⁵)
- Fatigue (17²⁶ to 61%²⁵)
- Dizziness (19²⁵ to 46%²⁶)
- Sinus congestion (51%²⁴)
- Skin irritation (38%²²)
- Shortness of breath (9²³ to 33%²⁴)
- Nausea (15²⁴ to 51%²⁶)
- Nasal irritation (20²⁶ to 43%²⁵)

The prevalence of these associated symptoms led to acknowledgement of a "**Sick Building Syndrome**" (SBS). The World Health Organization estimates that 30 percent of all new buildings may have problems that can lead to occupant complaints and illness. Others have hypothesized that it is possible that 20 percent of office workers (about 1.8 million people in Region 5) work in "sick buildings." The term **Building-Related Illness** (BRI) refers to more severe responses to indoor air pollutants. Examples of BRI include Legionnaires' Disease (which occurs mainly in hospitals and usually affects patients with kidney disease) and Hypersensitivity Pneumonitis, but there are few data on how many people may be suffering from BRI.

Another building-related diagnosis being increasingly accepted by clinicians is **Multiple Chemical Sensitivity** (MCS). MCS is a condition affecting a small subset of the population that has become sensitized to chemicals in the environment. Affected individuals appear to repeatedly suffer acute reactions upon exposure to pollutant levels commonly found in indoor environments. These exposures would not cause the majority of the population to experience discernible adverse effects.

Potential synergistic, antagonistic, and additive effects may play an important role in causing the acute symptoms associated with SBS and MCS. **Synergism** is known to exist among the following:

- PAHs and irritant gases (SO₂ and NO₂)²⁶
- PAHs and ETS²⁶
- Ozone and aerosols (ammonium sulfate)²⁷
- Asbestos and ETS²⁸
- NO₂ and aerosols (ammonium sulfate)²⁷
- Asbestos and BaP²⁹
- SO₂ and aerosols (sodium chloride)³⁰

Complex mixtures of chemicals are ubiquitous to indoor environments and are made up, in part, of environmental tobacco smoke (ETS), VOCs, pesticides, and combustion gases. (A subset of these pollutants have been found to be carcinogenic and are discussed individually in earlier sections.)

- **Environmental tobacco smoke** has been associated with cardiovascular effects, increased susceptibility to infectious diseases in children, chronic and acute pulmonary effects in children, mucous membrane irritation, and allergic responses.³¹
- **VOCs** have been identified a potential causative agent in SBS investigations.³² Health effects, reportedly attributable to exposure to VOCs, range from sensory irritation to behavioral, neurotoxic, and hepatotoxic effects.³³ Formaldehyde has been shown to cause mucous membrane irritation at very low concentrations (0.1 to 0.2 ppm) in chamber studies.³⁴
- **Pesticides** are by definition poisonous, and affect the nervous system, the hepatic system, and the reproductive system.³⁴
- **Combustion gases** that have been found to accumulate in indoor environments are carbon monoxide, nitrogen dioxide, and sulfur dioxide. The effects of CO may be grossly underestimated. One study reported that sensitive populations may be highly affected by indoor exposures and misdiagnosed with symptoms related to flu, food poisoning, Alzheimer's disease, and general decrepitude.³⁵ Nitrogen dioxide and sulfur dioxide are lung irritants that cause respiratory difficulty in sensitive populations, particularly asthmatics.³⁶
- **Airborne biological contaminants** are also ubiquitous in indoor environments. Biogenic aerosols can produce direct toxicity, or may be pathogenic or allergenic.³⁷

CAVEATS

This analysis of the approximate health impacts of poor indoor air quality is designed to be used only as part of a general comparison with other environmental problems. The quantitative risk estimates are based on generally accepted toxicity, exposure, and risk characterization methodologies and, therefore, carry all of the uncertainties typical of assessing risks (high-dose to low-dose extrapolations and animal-to-human extrapolations, for example). Further, this analysis has additional uncertainties resulting from the lack of specific data, particularly on exposures. For example, this analysis uses some common exposure information and generally applies those exposures on a 24-hour basis to all residents in the region. It does not attempt to rigorously account for differences in exposures by location (homes, offices, and schools, for example) or to distinct groups (sensitive populations, for example), or to account for the hundreds of chemicals found in indoor air. As a result, **the conclusions of this analysis are not appropriate for other purposes**. This analysis does, however, probably account for the major health effects from poor indoor air quality, at least as is now known.

ADDITIONAL INFORMATION

The derivations used in this analysis are available in the Documentation Report.

SUMMARY OF QUANTIFIED CANCER RISKS

Individual and Population Risks Carcinogenic Agents Region 5					
	Individual Risks			Population Risks	
	Lower	to	Upper	Lower	Upper
	---(lifetime risk)---			(annual excess cancer cases)	
VOCs:					
Formaldahyde	1 E-04	to	5 E-03	66 to	3507
Benzene	2 E-05	to	2 E-03	13 to	1288
Carbon tetrachloride	0E+00	to	2 E-03	0 to	1274
Chloroform	3 E-06	to	1 E-03	2 to	776
1,2 Dichloroethane	3 E-05	to	4 E-04	20 to	238
Tetrachloroethylene	8 E-05	to	3 E-04	56 to	200
Trichloroethylene	4 E-06	to	5 E-05	2 to	31
Benzo(a)Pyrene	4 E-06	to	1 E-05	3 to	8
Pesticides.					
Heptachlor	1 E-06	to	2 E-04	1 to	133
Aldrin	2 E-08	to	1 E-04	0.01 to	66
Chlordane	3 E-06	to	7 E-05	2 to	46
Dieldrin	1 E-07	to	3 E-05	0.1 to	20
alpha-BHC	4 E-07	to	2 E-06	0.3 to	1
4 4' DDE	6 E-08	to	4 E-07	0.04 to	0.3
Proxpur(Baygon)	3 E-08	to	4 E-07	0.02 to	0.3
ETS*	4 E-03	to	1 E-02	648 to	648
Asbestos	<u>7 E-06</u>	to	<u>3 E-03</u>	5 to	1988
Total Risk:	4 E-03	to	2 E-02	816 to	10,223

* Individual risks are for nonsmokers, population risk is computed considering additional subpopulations.

Note: Detail may not directly compute to population risk due to independent derivation of ETS risks and independent rounding.

Estimated 1990 population is 46378 thousand

Notes

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EPA Comparative Risk Study Indoor Air Quality Welfare Effects Assessment Region 5

Executive Summary

Poor indoor air quality can create a variety of economic costs to society including increased medical costs, losses to productivity, and damage to materials. The welfare effects of indoor air quality are estimated in this study using a damage approach (that estimates the cost of physical damage caused by a problem) to assign a value to the economic costs. Because of the lack of substantiated research in this area, the estimates are incomplete and subject to great uncertainty. The estimates are not statistically reliable and should be used only to compare the possible magnitude of the welfare effects of indoor air quality with the effects of other environmental problems.

Indoor air pollutants can cause damage to materials such as metals, paints, textiles, paper, leather, computer equipment, and electrical equipment. **Although the cost of material damage may be substantial, the value is not quantified** because of the lack of research in the area. The medical costs of indoor air relate to the cost of medical care for the health effects caused by indoor air. For Region 5, the **medical costs are estimated at \$175 million to \$410 million per year**. The costs of lost productivity consist of 1) reduced productive years due to major life-threatening health effects and 2) the day-to-day productivity losses of the general work force. **These productivity losses are estimated at \$9.5 billion to \$10.4 billion per year**. For effects quantified in this analysis, the **total welfare costs are about \$10 billion to \$11 billion per year** for Region 5.

Introduction

Very few studies are available on the economic costs of poor indoor air quality. In its *Report to Congress on Indoor Air Quality*¹, the U.S. Environmental Protection Agency (EPA) identified three major categories of economic costs: material costs, direct medical costs, and lost productivity costs. Using available research data, EPA quantified welfare costs for direct medical costs and lost productivity costs but was unable to assign a dollar value to the material costs. This analysis relies heavily on EPA's work as detailed in Chapter 5 of the *Report to Congress on Indoor Air Quality* for its methodologies and assumptions. Each of the three damage categories are described in detail in the following sections.

Materials Costs

Indoor air pollutants can cause adverse effects on materials and equipment. Costs associated with the adverse effects could include maintenance, repair, and replacement costs for soiling, deterioration of appearance, and reduced service life. Table 1 summarizes materials that can be affected, the types of possible damage, and the principal indoor air pollutants that can cause this damage.

As with health effects, some objects and materials can be considered a "sensitive population." Particularly sensitive objects include leather-bound books, fine art, electrical equipment, and computer equipment. The value of damage to unique art and antique books can be priceless. Telephone switching and computer equipment is susceptible to corrosion caused by air particles and gases. A representative of Bell Communications Research² reported that the seven regional telephone companies have spent large sums to replace, clean, or repair switches as a result of indoor air contaminants. Failures have occurred throughout the system, and range in cost from as little as \$10,000 to as high as \$380,000 per event. With the growing number of personal computers in use, the cost of damage to electrical equipment could be quite substantial.

**EPA Comparative Risk Study
Summary of Indoor Air Quality Issues**

Regions 2, and 4-9

Air Pollution Effects on Materials

Materials	Type of Damage	Principal Air Pollutants
Metals	Corrosion, tarnishing	Sulfur oxides and other acid gases
Paint and organic coatings	Surface erosion, discoloration, soiling	Sulfur oxides, hydrogen sulfides, particulate matter
Textiles	Reduced tensile strength, soiling	Sulfur oxides, nitrogen oxides, particulate matter
Textile dyes	Fading, color change	nitrogen oxides, ozone
Paper	Embrittlement, soiling	Sulfur oxides, particulate matter
Magnetic storage media	Loss of signal	Particulate matter
Photographic materials	microblemishes, "sulfiding"	Sulfur oxides, hydrogen sulfide
Rubber	Cracking	Ozone
Leather	Weakening, powdered surface	Sulfur oxides
Ceramics	Change of surface appearance	Acid gases, HF

Source: Report to Congress on Indoor Air Quality.

Volume II. Assessment and Control of Indoor Air Pollution August 1989 p. 5-6

Medical Costs

The annual number of **excess cancer cases** attributable to indoor air pollution are estimated and presented in the health effects section. The medical costs associated with the cancer cases, however, represent a welfare effect of indoor air. As in Chapter 5 of *Report to Congress on Indoor Air Quality*, the medical costs of the excess cancer are estimated using a 1981 study by Hartunian, *et al.*³ that estimates the present value of direct medical expenditures for various illnesses derived from actual cost experiences. Future medical costs were discounted to present value using a 6 percent discount rate.

The calculation of the medical costs due to excess cancer cases involves multiplying the number of excess cancer cases derived in the health effect analysis by the average cost per cancer case (available data are in 1986 dollars). Thus, the medical costs due to increased cancer cases for Region 5 equals 816 cancer cases multiplied by \$24,938 per case for a total of **\$20 million** at the low end of the range and 10223 cases for a total of **\$255 million** at the high end.

Chapter 5 of the *Report to Congress on Indoor Air Quality* calculates several other types of medical costs related to non-cancer health effects. The first cost relates to asthmatic children. A New York City study⁴ found that asthmatic children from smoking households visited hospital emergency rooms more often than those from non-smoking households. The cost of the **increased emergency room visits by asthmatic children** can be calculated as a welfare effect of poor indoor air. The New York City study reported that the number of increased emergency room visits equals 1.26 visits per year per asthmatic child in smoking home. The *Report to Congress on Indoor Air Quality* estimated, based on National Center for Health Statistics data, that 5 percent of children under 18 suffer from asthma. According to the Center for Disease Control, 43 percent of children live in smoking households. The cost of the additional emergency room visits equals the percent of children with asthma (5 percent) multiplied by the population of children under 18 to derive the number of children with asthma. Next, the number of children with asthma is multiplied by the percent of children in smoking households (43 percent) to get the number of asthmatic children in smoking households. That figure is then multiplied by the additional number of emergency room visits per year (1.26) and the average cost of the visits (\$90). For Region 5 the resulting cost is **\$30 million**.

Besides cancer, Environmental Tobacco Smoke (ETS) is reported to cause other major diseases. For example, according to a study by Wells⁵, 32,000 cases of **heart disease** per year (for the U.S.) are attributable to environmental tobacco smoke (ETS). In order to estimate the number of heart disease cases from ETS for Region 5, the number of heart disease cases are disaggregated from the country's total based on Region 5's population. The total medical costs for ETS heart disease equals the estimated number of cases for Region 5 (6097) multiplied by the medical costs per case (\$9,684) or **\$59 million**.

Another category of increased medical costs is due to **increased medical visits** for the white collar work force necessitated by indoor air quality problems. Based on a survey in New England⁶, white collar workers have an extra .26 visits with doctors per year due to poor indoor air quality. Assuming a white collar work force of 9131 million in Region 5 and an average cost per visit to the doctor of \$30⁷, the additional medical costs equals **\$66 million**.

Productivity Losses

The value of decreased worker productivity due to poor indoor air can also be included as a welfare effect. Decreased worker productivity falls into two categories: reduced productivity within the general work force and disease-specific productivity losses.

Within the general white collar work force, poor indoor air quality may cause a reduction in worker productivity due to headaches, eye irritation, and fatigue. Workers may also spend time away

from their work location by taking breaks or walks outdoors to relieve these symptoms. A study of 94 state government office buildings conducted by a coalition of employee unions⁸ found that 3 percent (or 14 minutes, or .23 hours) per day is lost due to poor indoor air quality. In addition, worker days lost due to sick leave were found to increase by an average of .6 extra sick days per worker per year.

The cost, then, of the reduced daily productivity per white collar worker equals the average white collar wage rate (\$15.56), multiplied by .23 hours/day times 2080 hours per year (52 weeks per year times 40 hours per week) multiplied by the Region 5 work force of 9131 million. The daily productivity losses for Region 5 equals \$9 billion. The productivity losses due to increased sick leave equals the wage rate multiplied by 4.8 sick hours, multiplied by the white collar work force in the region for a cost of \$682 million. The total **general worker productivity** losses for Region 5 (both lost time and sick leave) is estimated at **\$9179 million**.

Disease-specific lost productivity is measured based on the lost earnings caused by the increased number of cancer cases and cases of heart disease. Lost productivity costs due to **excess cancer cases** equals the number of cases multiplied by the cost of lost productivity per case (\$92,645) from the Hartunian Study⁹ or **\$76 million** at the lower end of the range and **\$947 million** at the high end. Lost productivity costs due to excess **heart disease** cases equals the number of cases multiplied by the cost of lost productivity per case (\$44,896) from the Hartunian Study¹⁰ or **\$247 million**.

* * * * *

Summary of Welfare Costs Attributable to Poor Indoor Air Quality Region 5

	Costs or Losses	
	Low	High
	-----(\$ million)-----	
Medical Costs		
Cancer	\$20	\$255
Noncancer		
Emergency room visits by asthmatic children	30	30
Heart disease	59	59
Increased visits to doctors by workers	<u>66</u>	<u>66</u>
Subtotal	\$175	\$410
Productivity Losses		
General worker productivity	\$9179	\$9179
Cancer	76	947
Heart disease	<u>247</u>	<u>247</u>
Subtotal	\$9528	\$10399
TOTAL	<u>\$9702</u>	<u>\$10809</u>

The largest portion of the welfare costs are attributable to lost productivity among the general white collar work force. These estimates for the white collar labor force productivity losses are in the billions of dollars and should only be considered a gross estimate to be used to compare the possible magnitude of the welfare effects of poor indoor air quality with the welfare effects of other environmental problems.

Notes

¹USEPA, *Report to Congress on Indoor Air Quality*, Office of Air and Radiation, Indoor Air Programs, EPA/400/1-89/001C, (Washington, DC: U.S. Government Printing Office), August 1989, Chapter 5, pages 5-1 - 5-21.

²Weschler, C., Bell Communications Research, Personal Communication with David Mudarri, EPA, June 30, 1988 as cited in *Report to Congress on Indoor Air Quality*, page 5-7.

³Hartunian, N. *et al.*, *The Incidence and Economic Costs of Major Health Impairments*, Lexington Books, 1981, as cited in *Report to Congress on Indoor Air Quality*, pages 5-7 - 5-8.

⁴Evans, D., *et al.*, "The Impact of Passive Smoking on Emergency Room Visits of Urban Children with Asthma", *American Review of Respiratory Diseases*, 135:567-572: summarized in *Residential Hygiene*, Vol. 4, No. 2, page 12, as cited in *Report to Congress on Indoor Air Quality*, page 5-10.

⁵Wells, A.J., "Passive Smoking Mortality: A Review and Preliminary Risk Assessment", Presented at 79th annual meeting, Air Pollution Control Association, Minneapolis, Minnesota. 1986, as cited in *Report to Congress on Indoor Air Quality*, page 3-6.

⁶*Report to Congress on Indoor Air Quality*, page 5-11.

⁷*Report to Congress on Indoor Air Quality*, pages 5-12.

⁸*Report to Congress on Indoor Air Quality*, page 5-11.

⁹Hartunian, N. *et al.*, *The Incidence and Economic Costs of Major Health Impairments*, Lexington Books, 1981, as cited in *Report to Congress on Indoor Air Quality*, pages 5-7 - 5-8.

¹⁰Hartunian, N. *et al.*, *The Incidence and Economic Costs of Major Health Impairments*, Lexington Books, 1981, as cited in *Report to Congress on Indoor Air Quality*, pages 5-7 - 5-8.

Radon

This paper provides information relating to environmental problem area # 21, Indoor Radon.

Data Acquired:

Recent radon sampling data for buildings on reservations were available through the Indian Health Service (IHS). Two data sets were available: results from about 250 buildings for which actual monitored readings were available, and test results from nearly 1000 buildings for which the only information reported was the proportion of readings exceeding 4 pci/l (EPA's "Action Level" for radon). Although both private homes and public facilities were monitored, we considered only samples from private homes. For each sampling site, results of either a canister test, an alpha track test, or both were available. In the cases where both tests had been performed, the results were averaged together. This procedure of averaging the results of a short term and a longer term test is not ideal. In general, the longer term test results should be more accurate. However, the number of longer term tests was quite small for many reservations and we wanted to use as large a data set as possible. There was no consistent difference between the short and the longer term test results. All samples for each reservation were averaged together to arrive at a representative level for the reservation. We assumed that the specific homes that have been monitored for radon on a reservation are representative of all the houses on the reservation.

For risk calculations, we used the smaller data set because it included information about the average radon levels observed. However, no data were available in this data set for four reservations. For these four reservations, we proceeded as follows:

- o Three of the reservations had no samples exceeding 4 pci/l (Bad River, Potawatomi, Red Cliff). These reservations were assumed to experience radon concentrations at the state average level of 1.7 pci/l.
- o For the Mole Lake reservation, it was assumed that the 31% of samples registering concentrations greater than 4 pci/l were at concentrations of 8 pci/l, and the remainder of the samples were at 1.7 pci/l.

The radon data are summarized in a table at the end of this paper. The estimated weighted average radon concentration in residences on Wisconsin reservations is 5.8 pci/l, well above the state average of 1.7 pci/l. The other Region 5 states average between 2.2 and 2.5, with the exception of Michigan at 1.1.

Human Health Risks:

A great deal of evidence has shown radon to produce lung cancer in humans. We calculated risks by using a simple model of radon potency (ignoring the interaction between

radon and smoking, and ignoring a back-calculation procedure for total lung cancer deaths). The excess lifetime cancer risk associated with EPA's action level of 4 pci/l is 1.7×10^{-3} . Applying this approach to the radon data for Wisconsin reservations, the excess risk varies in degree from reservation to reservation. The weighted average cancer risk is very high at 2.5×10^{-3} . The residents of the Stockbridge-Munsee, Menominee, Mole Lake, and Lac du Flambeau reservations appear to face the greatest risks.

Ecological Risks:

There are no ecological risks associated with indoor radon.

Social and Economic Damages:

Health care costs and lost wages associated with lung cancer are expected to be significant. EPA recommends remediation of homes where radon concentrations exceed 4 pci/l. Remediation can involve a variety of measures ranging from simple improved ventilation to ventilation with air-to-air heat exchangers to sub-slab ventilation. Remediation costs might typically be in the range of \$500 - \$2,500 per household, depending on the complexity of remediation. Assuming remediation would be undertaken in about 750 houses (the estimated number of Indian residences with concentrations exceeding 4 pci/l), total remediation costs could reach over \$375,000 in one-time costs. It should be noted that since remediation reduces health risks associated with exposure to radon gas, the residents of a remediated house will experience decreased health risks. That is, residents will bear either the full calculated health risks and health care costs and lost wages (if no remediation occurs), or the remediation costs plus somewhat reduced health risks.

INDOOR RADON ON WISCONSIN RESERVATIONS

Reservation	County	Number of households	Data Set 1		Data Set 2		Average Est. Radon Level (pci/l)	Excess Individual Risk (avg)
			Avg. Radon Level (pci/l)	# of Samples	% Samples > 4 pci/l	# of Samples		
Bad River Chippewa	Ashland, Iron	185	-	-	0%	17	1.7	7.2E-04
Lac Courte Oreilles Chippewa	Sawyer	392	3.8	8	18%	97	3.8	1.6E-03
Lac du Flambeau Chippewa	Vilas, Iron	304	8.1	13	26%	80	8.1	3.4E-03
Menominee	Menominee	657	8.9	129	46%	328	8.9	3.8E-03
Mole Lake Chippewa	Forest	64	-	-	31%	13	3.7	1.6E-03
Oneida	Brown, Outagamie	797	6.8	10	16%	128	6.8	2.9E-03
Potawatomi	Forest	73	-	-	0%	6	1.7	7.2E-04
Red Cliff Chippewa	Bayfield	240	-	-	0%	19	1.7	7.2E-04
St. Croix Chippewa	Polk, Burnett	195	3.9	1	6%	33	3.9	1.7E-03
Stockbridge - Munsee	Shawano	148	7.8	83	54%	184	7.8	3.3E-03
Winnebago	Jackson	693	5.2	6	9%	56	5.2	2.2E-03
Total # households:		3748	Wgtd. Avg. Radon Level:		5.8		Wgtd. Avg. Excess Risk:	
					2.5E-03			

NOTE -- The risk calculations are for non-smokers. EPA's Office of Radiation Programs estimates that smokers face risks about fifteen times higher than non-smokers.

General References

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U.S. Department of Commerce. 1990 Census Population Data for American Indian Reservations with Populations exceeding 1,000. Press release. 11 July, 1991.

U.S. Environmental Protection Agency, Region 5. Comparative Risk Project Results.

U.S. Environmental Protection Agency. Integrated Risk Information System and Risk Assistant software for information on health effects of toxic substances and assistance in risk calculations.